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AERONAUTICAL RESEARCH LABORATORIES

MELBOURNE, VICTORIA

Aerodynamics Technical Memorandum 383

VALIDATION OF THE ARL MATHEMATICAL MODEL OF THE SEA KING MK 50 HELICOPTER

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M.J. WILLIAMS and A.M. ARNEY

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SUMMARY

A mathematical model of the Sea King Mk 50 helicopter has been developed at ARL to allow prediction of the aircraft flight behaviour for a wide range of specified conditions. Validation of the model has been performed by successive comparisons with flight data and model adjustment to achieve acceptable overall agreement. Such comparisons have been made for trimmed flight, dynamic responses to control inputs and automatic transitions associated with the ASW role. Some remaining deficiencies in the model could be addressed by modifications tailored to a specific application.

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CONTENTS

1. INTRODUCTION

A mathematical model of the Sea King Mk50 helicopter, as used in the ASW role, has been developed by ARL to a Royal Australian Navy (RAN) task requirement. This model has been described in general terms in Refs 1 and 2. Full descriptions of the main components, namely, the Aerodynamics/Kinematics, Control Systems and Cable/Sonar may be found in References 3-8. Detailed instructions for the running of the mathematical model on the ARL computer may be found in Ref. 9.

The purpose of this memo is to compare the aircraft behaviour predicted by the model with that observed during flight trials (Ref. 10). Up to the present, results of this validation exercise fall into three categories, namely trimmed flight, dynamic responses and examples of other manoeuvres which include the automatic transition associated with ASW operation. The scope of the validation is discussed more fully in the next section.

For each of the three categories above, a section of this paper is allotted for presentation of validation results together with discussion of factors, unknown or difficult to model, which may be the source of discrepancies. It must be borne in mind that the model has basic assumptions and simplifications, particularly in respect of the rotor aerodynamics, in order to obtain more tractable analytic expressions. Also, the complex interactions of rotor downwash with the fuselage, empennage and tail rotor cannot be adequately modelled and use must be made of empirically based functions.

As will be shown, the present model is believed to be an adequate representation of the Sea King flight behaviour for a wide range of conditions including operations in the ASW role.

2. SCOPE OF VALIDATION

A large data bank derived from an extensive series of Sea King flight trials (Ref. 10), is presently available. The main purpose of the trials was the acquisition of data for validation of the mathematical model.

An additional benefit of the trials was that the results could be useful in the more general field of flight behaviour studies.

The present validation has been limited to categories which encompass the most likely areas of application in the foreseeable future.
These are:

(i) Trimmed flight performance over a range of airspeeds up to 120 kn. Rearward and sidewards flight conditions are included. Parameters used for comparison are aircraft attitudes, blade angles, torque and control settings.

(ii) Dynamic response tests, wherein the effect on aircraft response of a variety of inputs to each of the control channels is studied. This aspect of the trials program covered a range of airspeed from hover to about 88 kn with the autostabilizer (ASE) both 'ON' and 'OFF'. The validations presented here are for a representative selection of cases with emphasis placed more on the ASE 'ON' cases since this is how the aircraft is normally flown. This also avoids the large cross couplings and instabilities which occur with ASE 'OFF'.

(iii) Other examples of validation presented include the following:

(a) Automatic transition manoeuvres both 'DOWN' and 'UP' which are used in the anti-submarine warfare (ASW) role prior to and subsequent to the dunking of the SONAR transducer. The automatic transition capability is also useful in the search and rescue (SAR) role.

(b) An engine cut to simulate the effect of the loss of one engine. The remaining engine is programmed to accept the extra load (within transmission limits) and validation is a test of the adequacy of the somewhat simplified engine model.

(c) Use of the flight control system beeping facility demonstrates the effect of more gradual inputs when compared with the rapid control movements used in the dynamic response tests.

3. TRIMMED FLIGHT

The achievement of steady conditions, with all time derivatives equal to zero, is defined to be trimmed flight. Ideally, trimmed flight trials should be performed in near-zero wind conditions so that airspeed may be deduced from ground speed measurements. This is particularly important at low speeds where conventional airspeed measuring devices are notoriously unreliable. Most of the present data were derived in low wind conditions during successive passes along a runway where ground speed was maintained by reference to a pacer vehicle for the lower speeds. For the higher speed runs, ground speed was deduced from the elapsed time between runway markers. Concurrently, the aircraft Doppler instrumentation was calibrated for use in later tests which included a series of high speed trim flights away from the airfield.

From the earlier series of airfield flights, use was made of Doppler, heading, and sideslip instrumentation to determine the prevailing wind conditions. The wind speed averaged 9 knots with the direction 90 degrees across the runway. Thus for the low speed fore-aft flight the wind was 90° to starboard, and head on for the sideways flight tests. Immediately following these tests the higher speed runs were performed above another runway. The wind direction in this case was from 35° to starboard of the aircraft heading.

Flight data presented in Figs 1,2,3 therefore pertain to tests at various wind directions and include some changes in AUW arising from fuel usage. In running the model for comparison, an average AUW of 19200 lb was taken and zero wind speed assumed. However some model runs showing the effects of a 9 knot wind are also presented.

3.1 Torque

The effect of allowing for a 9 knot wind is clearly shown in the low speed region where the measured torque at 'hover' is less than might be expected in zero wind conditions. At high speeds the model underestimates the observed flight data for which several factors could be responsible. Firstly, the effects of retreating blade stall are not allowed for in the model. Secondly the effects of compressibility deduced from Reference 11 may be conservative. Finally, the parasite drag estimate using an equivalent flat plate area of 35 ft^2 may be in error. Values of 31 ft^2 are given in Reference 12 whilst the mathematical model of Reference 13 used 44ft^2. This latter value seems high and may have been chosen to remedy a torque deficit similar to the present model.

In sideways flight the model shows good agreement when the presence of the prevailing 9 knot wind is allowed for.

3.2 Roll and Pitch Attitudes

Roll and pitch attitude trends are well predicted by the model. In the roll case (Fig. 1b) it can be seen that a 1 deg. increment is needed to offset the effect of a 9 knot ambient wind from starboard. Pitch attitude is unaffected by the side wind. The good agreement shown is to be expected since an empirically based function in the model (Ref. 3.) has been tailored to represent the rotor downwash effects in the tail region.

In sideways flight the roll trend is reasonably predicted, however for the pitch case some discrepancy is evident at the higher speeds to starboard. Some of these differences may be attributed to the effectiveness in modelling the aforementioned downwash effects but some may reflect the difficulty in trimming a real helicopter in sideways flight.

3.3 Blade Angles

The tail rotor blade angle, θ_T, (Fig. 2a) shows good agreement for forward flight but in rearward flight the aircraft requires more pitch than predicted. This is also the case in right sideways flight, thus suggesting the presence of boom side forces arising from downwash which are not accounted for in the model. Reference 14 demonstrates that the effect of fitting a strake to a Sea King tail boom is to greatly reduce the blade pitch requirements., the strake effectively destroying flow circulation around the tail boom.

The main rotor collective pitch angle at 75% radius, θ_{C75}, (Fig. 2b) shows the degree of agreement directly analagous to that for torque (Fig. 1a) in that any deficiencies in torque prediction will show in θ_{C75}.

Cyclic blade angles (Figs 2c,d) correctly indicate trends in the fore-aft case with a discrepancy averaging about 1 degree. At the highest speed the longitudinal cyclic deficiency becomes larger and probably reflects the model underestimate of torque (power) noted in Fig. 1a.

In sideways flight, the prediction of longitudinal cyclic pitch, B_{1S}, is quite good. In the case of lateral cyclic, A_{1S}, despite reasonable agreement in sideways flight to starboard, the results show different trends with increasing speed to port. The reason for this unexpected divergence is not yet understood, but may derive from the inherent assumptions in the rotor aerodynamics e.g. uniform inflow, stiff blades etc. which in turn give poor estimates of lateral flapping angle. The previously-mentioned tail boom side forces may also be a factor.

3.4 Control Positions

Figures 3a-d show a comparison of the model prediction and flight for the autostabilizer (ASE) both "ON" and "OFF" and zero wind conditions. The degree of agreement shown in the cases of pedal and collective stick is essentially a reflection of that previously shown for the blade angles θ_T and θ_{C75} respectively.

While the lateral and longitudinal stick positions show the correct trends for both the ASE "ON" and "OFF" cases there are discrepancies in the absolute values. The predicted lateral stick values are about 3 deg. and 2 deg. too high respectively while the longitudinal values are on average 2 deg. low for both cases.

It should be noted that with ASE "ON" some uncertainty in the measured control positions may stem from the fact that the respective positions of the servo trim potentiometers on the pilot's controller were not monitored during trials. On the other hand null trim inputs were assumed for the model. This problem does not arise with ASE "OFF", so that the discrepancy in lateral stick position is linked with that noted for blade cyclic angle A_{1S}. Similar observations apply to the longitudinal channel.

4. DYNAMIC RESPONSE

For this phase of the validation it is desirable that all those quantities influencing the flight trials responses are matched as closely as possible by the math model run. This is ensured by adding the measured control variations to the initial model trim values for each run. This, and other points relevant to running the model are fully described in Reference 9. For each flight for which data are being used for validation, the model uses average values of air density, wind speed and direction. In addition, a choice of two sets of trimmed conditions is available, which correspond to the range of AUW and inertias obtained during the flight as a result of fuel usage.

As mentioned earlier, validation is hard to assess with the autostabilizer disengaged because instability occurs in both the model and flight behaviour. For the normal operational ASE "ON" case it follows that the Aerodynamics/ Kinematics component alone cannot be assessed and validation includes also the Systems modelling.

Most comparisons presented in this Section therefore pertain to the ASE "ON" case and in turn deal with the responses to varying control inputs to the cyclic, pedal and collective channels both at hover and 88 kn airspeed. For comparison, an example of the unstabilized response is given for each control.

4.1 Longitudinal Cyclic Inputs

Figs 4a,b show results for hover conditions with step inputs of opposite sense. In each case the primary pitch rate responses are well modelled with the mathematical model having a slightly faster rise time. In each case however the coupled roll responses are somewhat over-estimated.

At 88 knots the same comments generally apply as shown in Figs 5a,b,c for step inputs and the more complicated pulse input. It may be noted that the predicted coupled roll rate response correlates directly with the pitch rate whereas the flight roll rate is delayed by some 0.3s.

A significant additional response at 88 kn is that of the vertical accelerometer, essentially load factor variation, where peak values of 0.3g are reasonably well modelled in Fig. 5b. Because equal and opposite blade pitch changes are input on the advancing and retreating side of the disk, there is a proportionally greater change in angle of attack on the advancing side. A positive B_{1S} input means a reduction in pitch on this side and the resultant initial response, enhanced also by the presence of inflow lag, resembles that for a collective pitch reduction. This may be seen by comparing Fig. 5b with a later Fig. 12a.

4.2 Lateral Cyclic Inputs

Hover results for step inputs of opposite sense are shown in Figs 6a,b. The predicted primary roll rate responses are generally about 30% too high while some small coupled pitch response is also predicted which is negligible in flight data.

These observations generally apply in the 88 kn cases shown in Figs 7a,b. However, the model responds also to produce variations in rotor speed and torque which are somewhat greater than observed in flight. Here the rotor load, and consequent speed variation arising from roll rate appears to be of opposite sign to that of the model.

Although the present validation is predominantly concerned with the stabilized case, ASE 'ON', it is of interest to include 2 examples of cyclic inputs with the ASE 'OFF'. Fig. 8a treats the case of longitudinal cyclic input at 88 knots which may be compared with Fig. 5c. Likewise for the lateral input, Fig. 8b may be compared with Fig. 7a. It may be seen that modelling of the initial responses is quite good but shows similar modelling deficiencies (such as 'roll rate response') as in the ASE 'ON' case in respect of excessive cross-coupling.

The cyclic responses represent the simplest cases compared with pedal and collective inputs where rotor speed and engine control assume greater importance.

4.3 Pedal Inputs

Examination of the flight data for pedal inputs with ASE 'OFF' has shown that the pedal movements and auxiliary servo outputs do not always show the correspondence expected from the static gearing ratio measured in ground tests.

This correspondence worsens for the more rapid inputs which suggests the probable influence of pedal dampers and yaw force link in the control run. Operation of the yaw force link depends on the foot pressure applied by the pilot, whilst the damping depends on the pedal velocity. Unfortunately neither of these parameters was included in the model and therefore not measured during the flight trials.

As a consequence, when running the model to replicate the measured control variations, as for the other channels, the auxiliary servo rod movements are added to the initial model trim value. Naturally the contributions of the pilot and the ASE to the servo output cannot be individually determined. In the graphs presented here, the math model values for the pedals are included only to indicate the input required to produce the blade angles in the absence of ASE signal and non-linearity in the control run.

This uncertainty imposes a limitation on the use of the model when the aircraft response to specified pedal movements has to be predicted. The extent of the limitation will depend on the rate of pedal input.

The effects of a step input at hover are shown in Figs 9a,b, for opposite senses. Yaw rate responses are well predicted and show the expected differences in rates for nominally similar pedal movements in flight. The more complicated pulse input (Fig. 9c) shows a good result although the coupled roll response and engine parameters of the model are 'over-active'. Figs 10a,b for the 88 knot case show similar behaviour to that for the hover with the primary yaw rate response well predicted. The ASE 'OFF' case is shown in Fig. 10c and may be compared with Fig. 10a. The most noticeable difference is that the model roll rate has not stabilized. Otherwise the yaw rates are well modelled with the ASE 'OFF' case indicating the strong aerodynamic yaw stabilization at the higher speeds.

4.4 Collective Inputs

During the flight tests with ASE 'ON' the aircraft was stabilized in pitch, roll and yaw but height holds were not engaged. Thus the blade pitch was solely determined by the collective lever position. These conditions have been duplicated in the math model with flight values of collective stick movement added to the model initial value.

The responses to collective step inputs of opposite sense are shown in Figs 11 a,b. The primary response is seen in the vertical accelerometer (load factor) where the peak values experienced in flight are not well-modelled in spite of some allowance in the model for inflow lag. The rapid changes in flight loads are possibly the result of blade flapping dynamics which are not accounted for in the quasi-static type of model. The inplane moments arising from blade lag motion directly affect shaft torquemeter reading and rotational speed. Again the modelling of the rotor drive and engine system does not include this degree of complexity but the model responses still give a fair representation. The pulse input of Fig. 11c provokes large torque and load factor variation well after the stick movement has finished while the vertical acceleration hardly varies.

Results at 88 knots are shown in Figs 12a,b,c. The step input (Fig. 12a) when compared with the same input at hover (Fig. 11b) shows similar peak acceleration. However the ensuing torque variations have a longer period and as expected the yaw rate damping is increased. Generally the responses are well modelled. As for the hover case, a pulse input initiates large torque variation. It is likely that the duration of the pulse used in flight is not far removed from a fundamental frequency associated with the fuel control system or blade inplane dynamics. The ASE OFF case is represented by Fig. 13 which is comparable with Fig. 11b. Here the flight data are quite similar with the benefits of attitude stabilizing clearly evident. Without ASE input to stabilize it the model behaviour diverges from the flight record within 2 or 3 seconds in Fig. 13.

5. OTHER MANOEUVRES

5.1 Transitions

These manoeuvres are an essential part of ASW operations and reduce the pilot workload by automatically transitioning (DOWN) from cruising flight to the hover required for sonar dunking operations. On completion of the dunking phase a transition (UP) takes the aircraft to the cruise condition.

Model and flight results are compared in Fig. 14a for the 'DOWN' case. Generally the trends are well predicted by the model, although some periodicity is evident in the initial half of the run in respect of roll rate, torque and rotor speed. The period of about 4s is greater than that associated with the engine control and suggests an aircraft response, perhaps to wind fluctuations or heavy seas affecting the radio altimeter. The vertical accelerometer certainly indicates higher transient loads in the initial 40s. Note also that as hover is approached the vanes are greatly affected by rotor downwash.

In the case of the transition 'UP' shown in Fig. 14b the combination of accelerating and climbing flight tends to produce less variation in torque and the periodicity is not as evident in roll rate and rotor speed. Again, the vertical accelerometer indicates more fluctuation at the higher speed and altitude.

Generally, the trends predicted by the model agree well with the flight results.

5.2 Engine Cuts

These flight tests were performed to simulate the case of the failure of one engine. In such an event the engine management system calls on the remaining engine to make up the power loss, provided engine and transmission ratings are not exceeded.

This manoeuvre has been validated as it represents a check of engine modelling without the additional effect of moving the collective stick and hence the engine operating point. Comparison of model and flight data is shown in Fig. 15 and while agreement is generally good it can be seen that the torque and rotor speed response of the model are not damped as much as the flight results. Some "fine tuning" of the engine would improve this but the simplified nature of the model necessarily means some compromises have to be accepted in order to obtain adequate results in other situations , for example, pedal and collective dynamic responses. A significant difference occurs in the initial response of the vertical accelerometer. The model trend indicates a load reduction whereas the flight data indicate greater loading even though power is reduced. This could result from a transient reduction in lag angle and consequent pitch increase from pitch-lag coupling.

5.3 Beeping Trim Inputs

The beeper trim system allows fine adjustment of the cyclic stick position by pilot controlled stick trim switches. The rate of stick movement depends on whether longitudinal or lateral movement is selected. In the ASW mode beeping operates automatically to extend the servo valve authority.

The manual beeping capability of the model is validated here because such inputs represent comparatively slow stick changes compared to those used in the dynamic response tests and are more representative of normal pilot practice.

Fig. 16a relates to a forward beep. It can be seen that the increasing forward velocity and more nose-down attitude are well modelled. The vertical accelerometer flight data differ initially and respond to the longitudinal acceleration. The transient acceleration of opposite sign noted in Fig. 5b for a rapid cyclic step forward is not present.

An example of lateral beeping is shown in Fig. 16b for the starboard case. Model trends correlate well with flight data except for the channels associated with the pedal controls. In view of the earlier discussion in Section 4.3, regarding the yaw force link and pedal damper, this discrepancy must be accepted at this stage of model development.

6. CONCLUDING REMARKS

Validation of the ARL mathematical model of the Sea King Mk50 helicopter has been performed over a wide range of operating conditions using flight trials data.

The model is considered to give an adequate representation of the helicopter behaviour for trimmed flight over a range of airspeed, and dynamic response to control inputs. Other manoeuvres which the model is capable of calculating with a good degree of success include ASW transitions, simulated engine failure and beeper trim inputs.

Some particular deficiencies in the model have been noted. They affect results in the areas of:

(a) Lateral cyclic pitch and control position trim values in sideways flight,
(b) roll cross-coupling with longitudinal cyclic inputs,
(c) torque and rotor r.p.m. dynamics with lateral cyclic inputs and engine cuts,
(d) vertical accelerometer response to collective step inputs.

These deficiencies may be attributed to the simplified rotor and interactional aerodynamics representations used and to simplifications in the engine model. Work is currently in progress to improve these aspects and to account for the effects of blade flap and lag dynamics.

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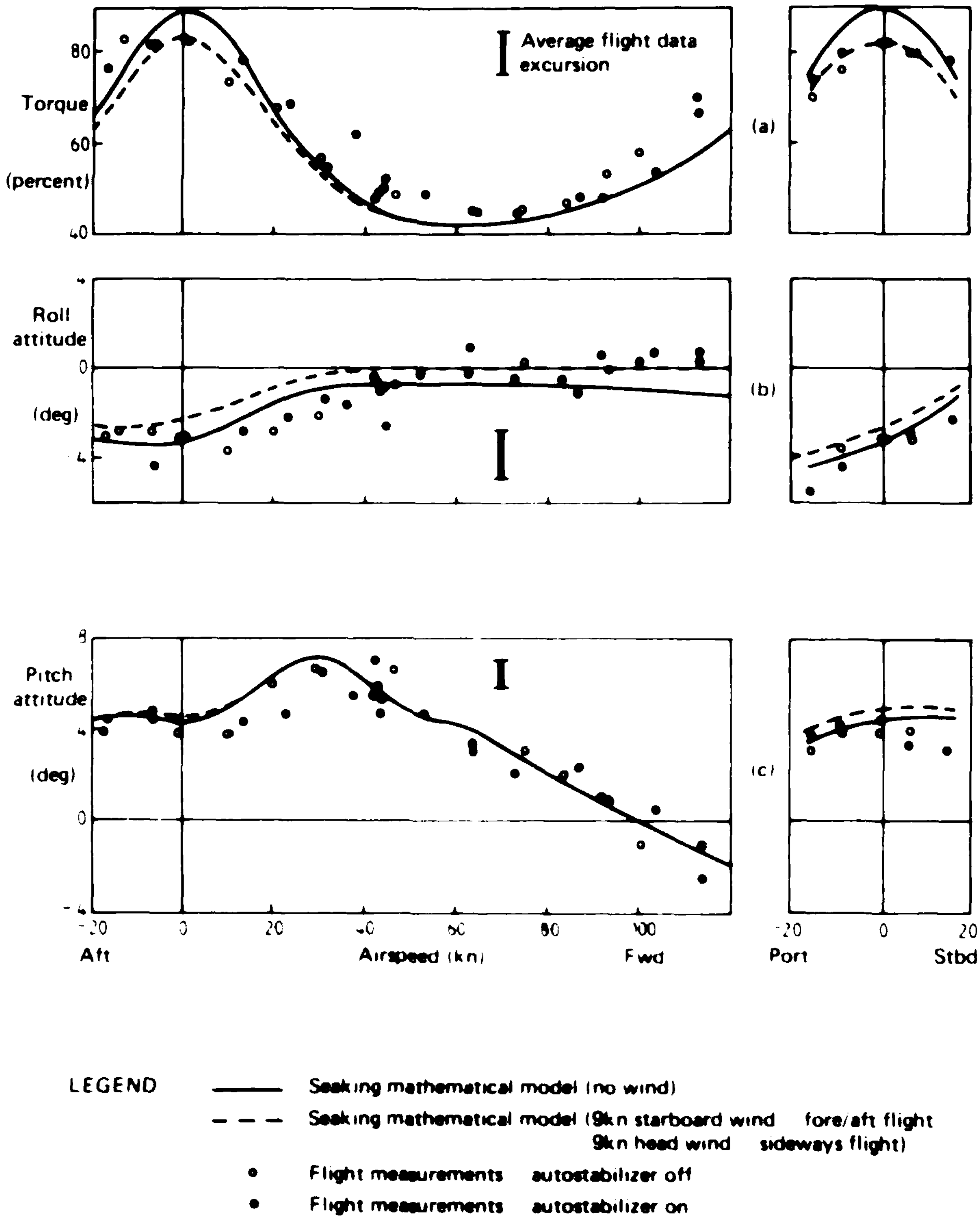
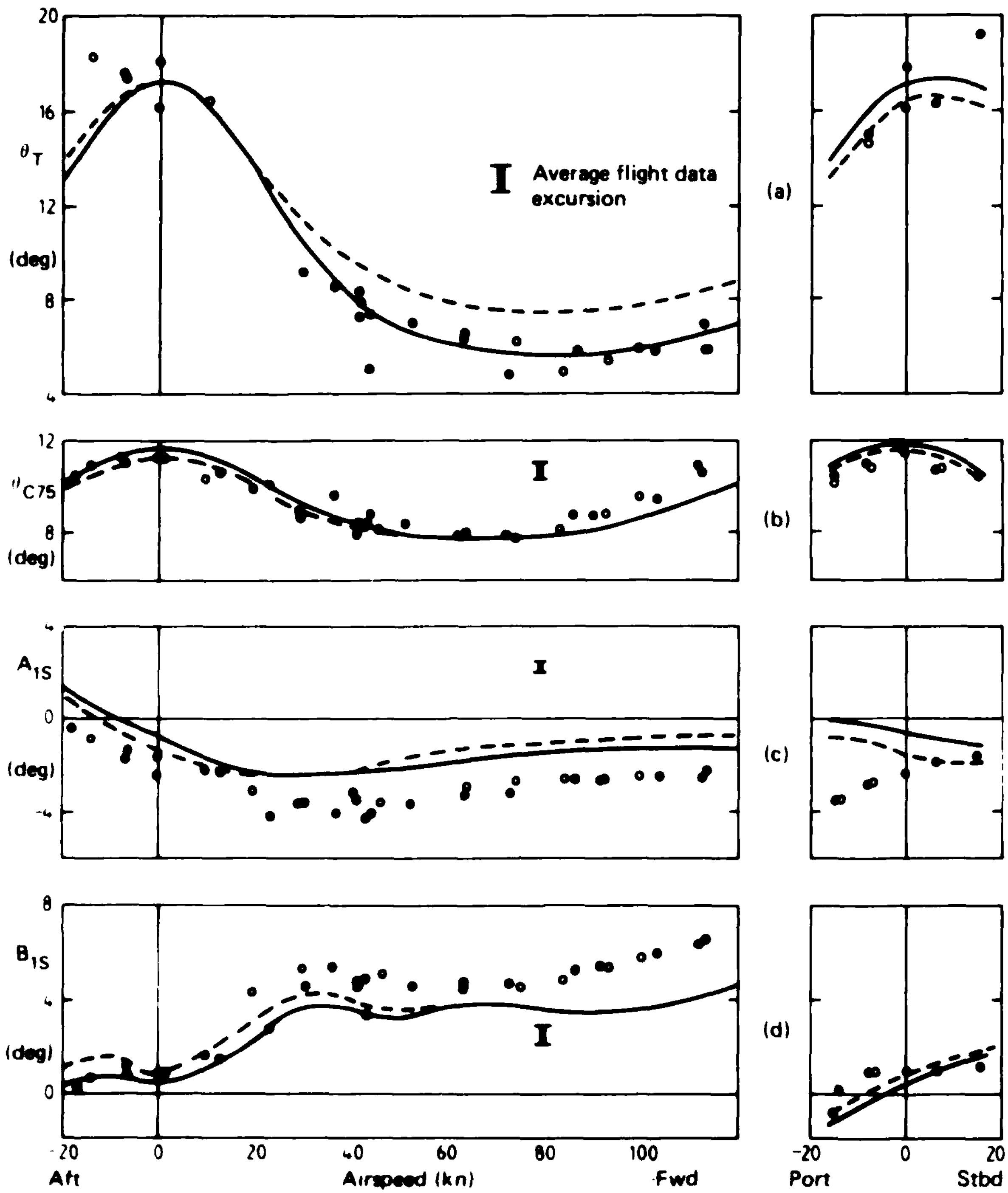


FIG. 1 COMPARISON OF SEAKING MATHEMATICAL MODEL WITH TRIMMED FLIGHT MEASUREMENTS TORQUE, ATTITUDES



LEGEND

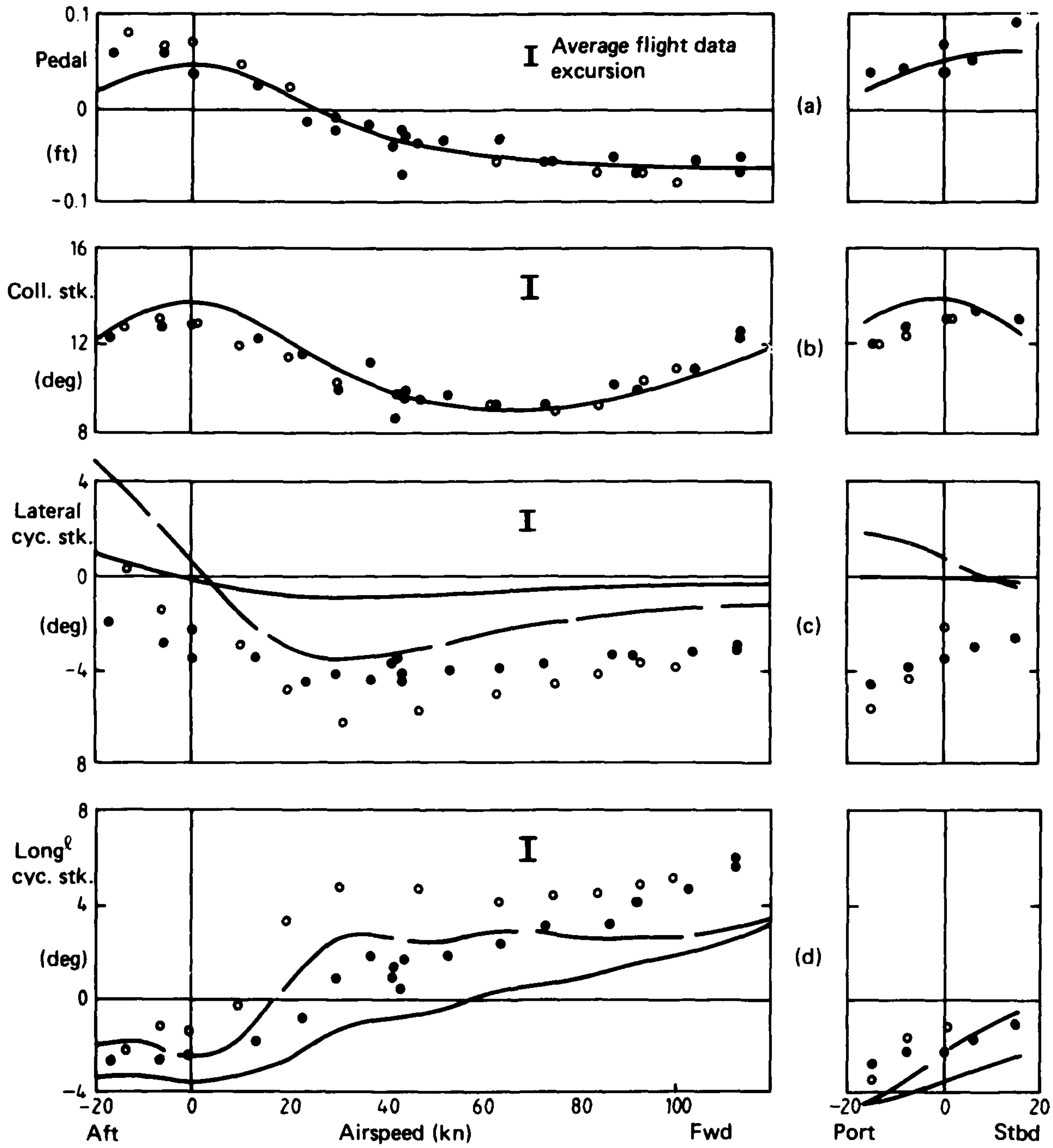
—— Seaking mathematical model (no wind)

- - - Seaking mathematical model (9kn starboard wind – fore/aft flight 9kn head wind – sideways flight)

• Flight measurements - autostabilizer off

• Flight measurements - autostabilizer on

FIG 2 COMPARISON OF SEAKING MATHEMATICAL MODEL WITH TRIMMED FLIGHT MEASUREMENTS BLADE ANGLES



LEGEND

— — Seaking mathematical model (no wind – autostabilizer off)

—— Seaking mathematical model (no wind – autostabilizer on)

○ Flight measurements – autostabilizer off

● Flight measurements – autostabilizer on

FIG. 3 COMPARISON OF SEAKING MATHEMATICAL MODEL WITH TRIMMED FLIGHT MEASUREMENTS – CONTROL POSITIONS

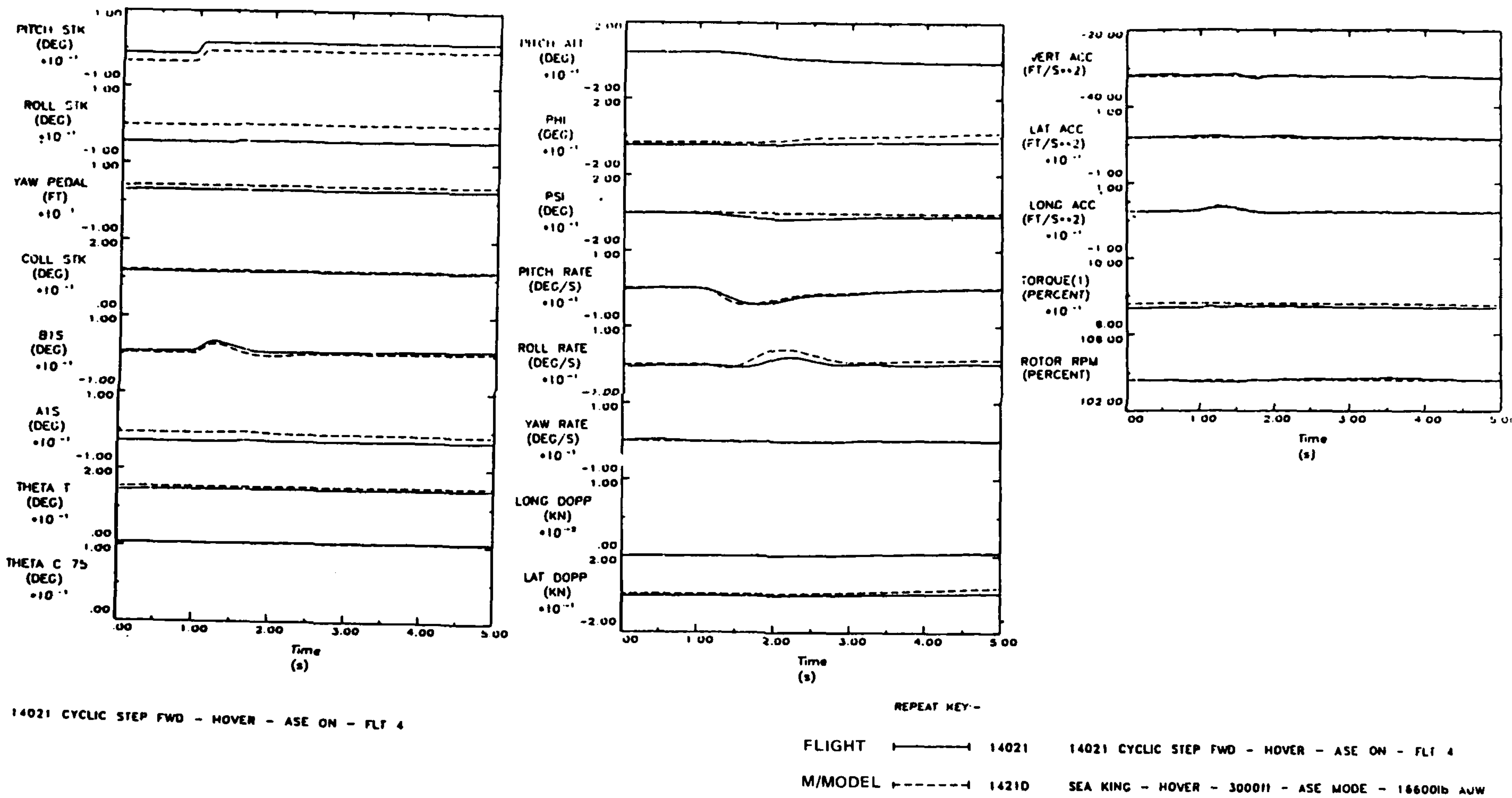


FIG. 4(a) DYNAMIC RESPONSE – LONGITUDINAL CYCLIC INPUT

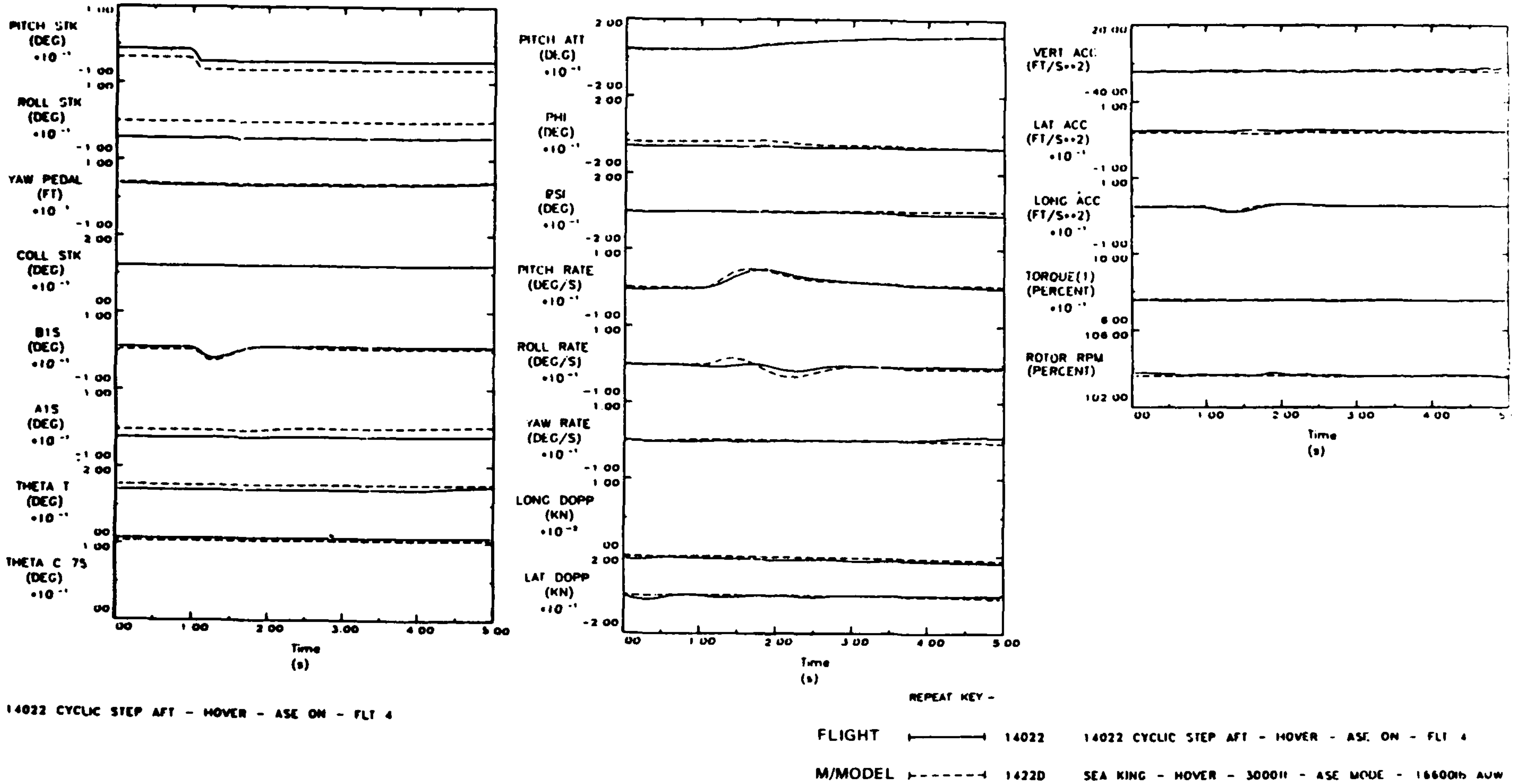


FIG. 4(b) DYNAMIC RESPONSE – LONGITUDINAL CYCLIC INPUT

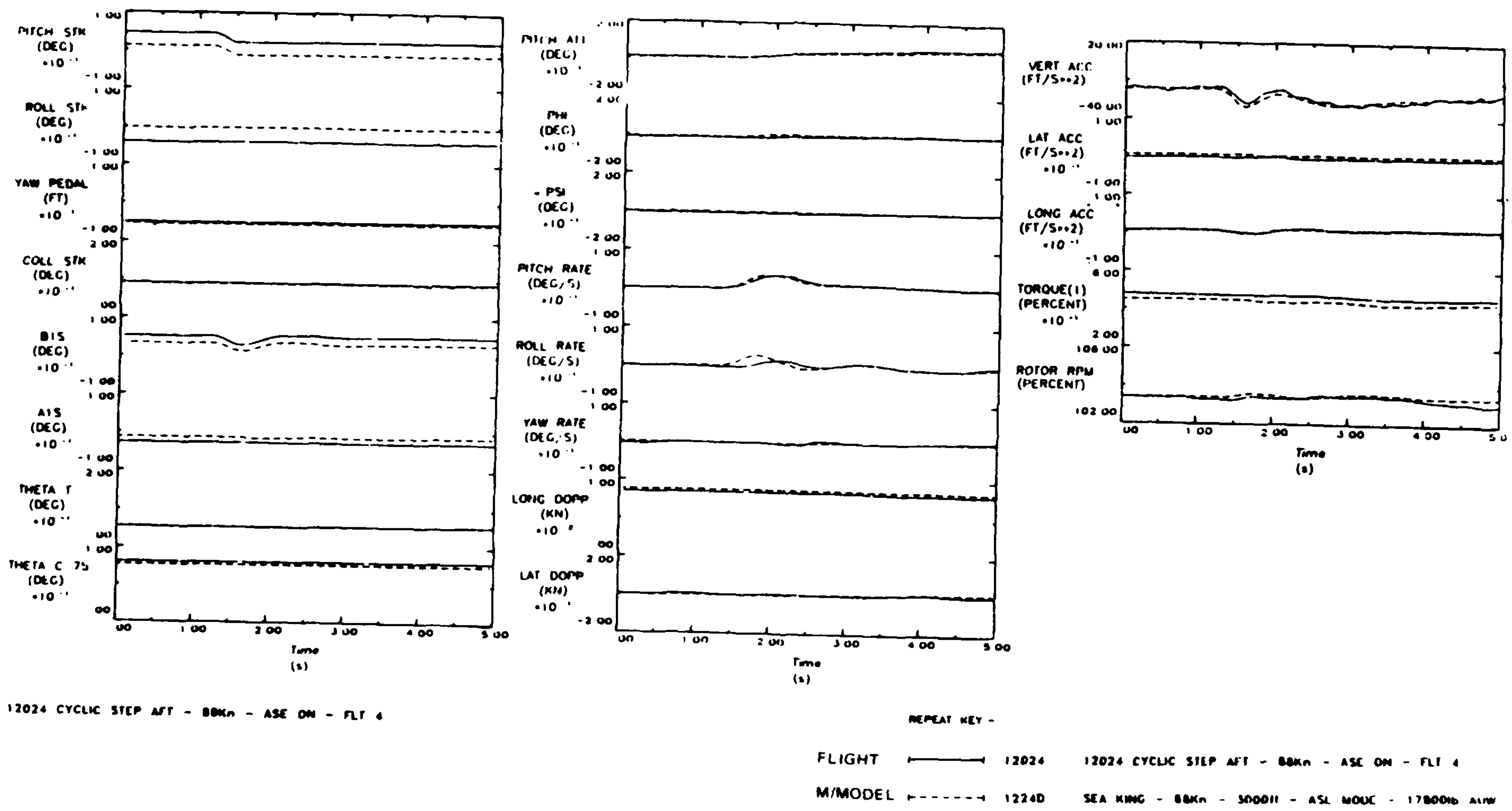


FIG. 5(a) DYNAMIC RESPONSE – LONGITUDINAL CYCLIC INPUT

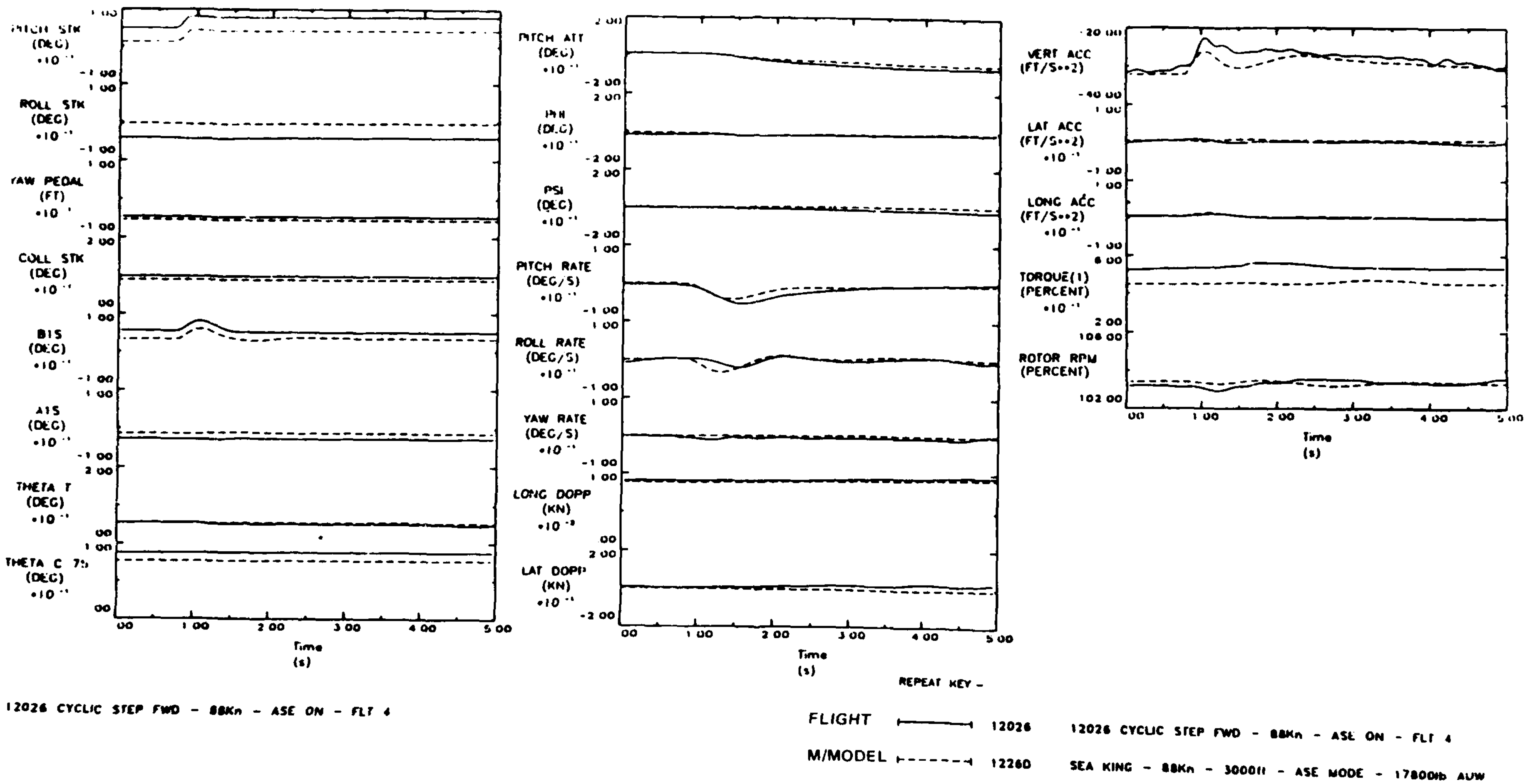
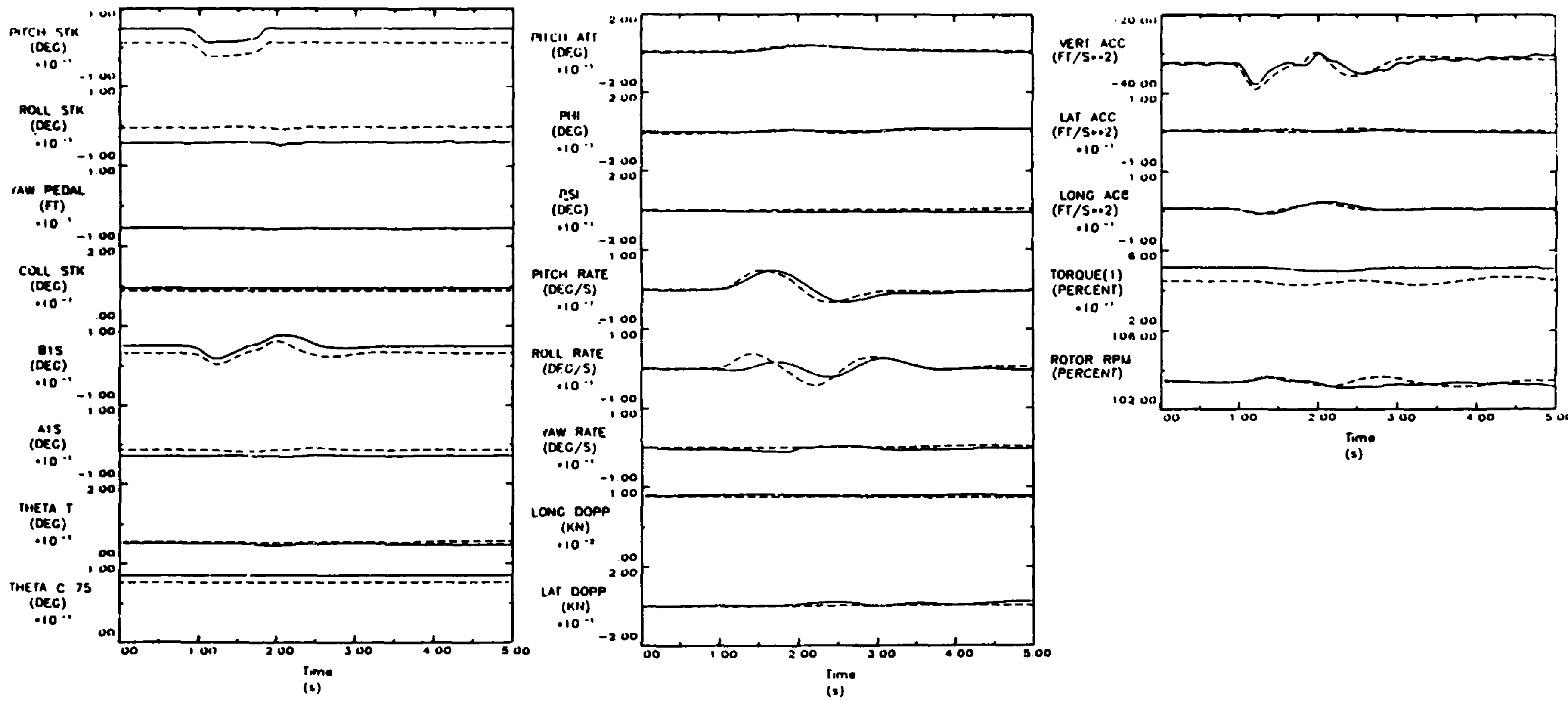


FIG. 5(b) DYNAMIC RESPONSE – LONGITUDINAL CYCLIC INPUT



12028 CYCLIC PULSE AFT - 88Kn - ASE ON - FLT 4

REPEAT KEY -

FLIGHT	├──────┤	12028	12028 CYCLIC PULSE AFT - 88Kn - ASE ON - FLT 4
M/MODEL	├------┤	1228D	SEA KING - 88Kn - 3000ft - ASE MODE - 17800lb AUW

FIG. 5(c) DYNAMIC RESPONSE – LONGITUDINAL CYCLIC INPUT

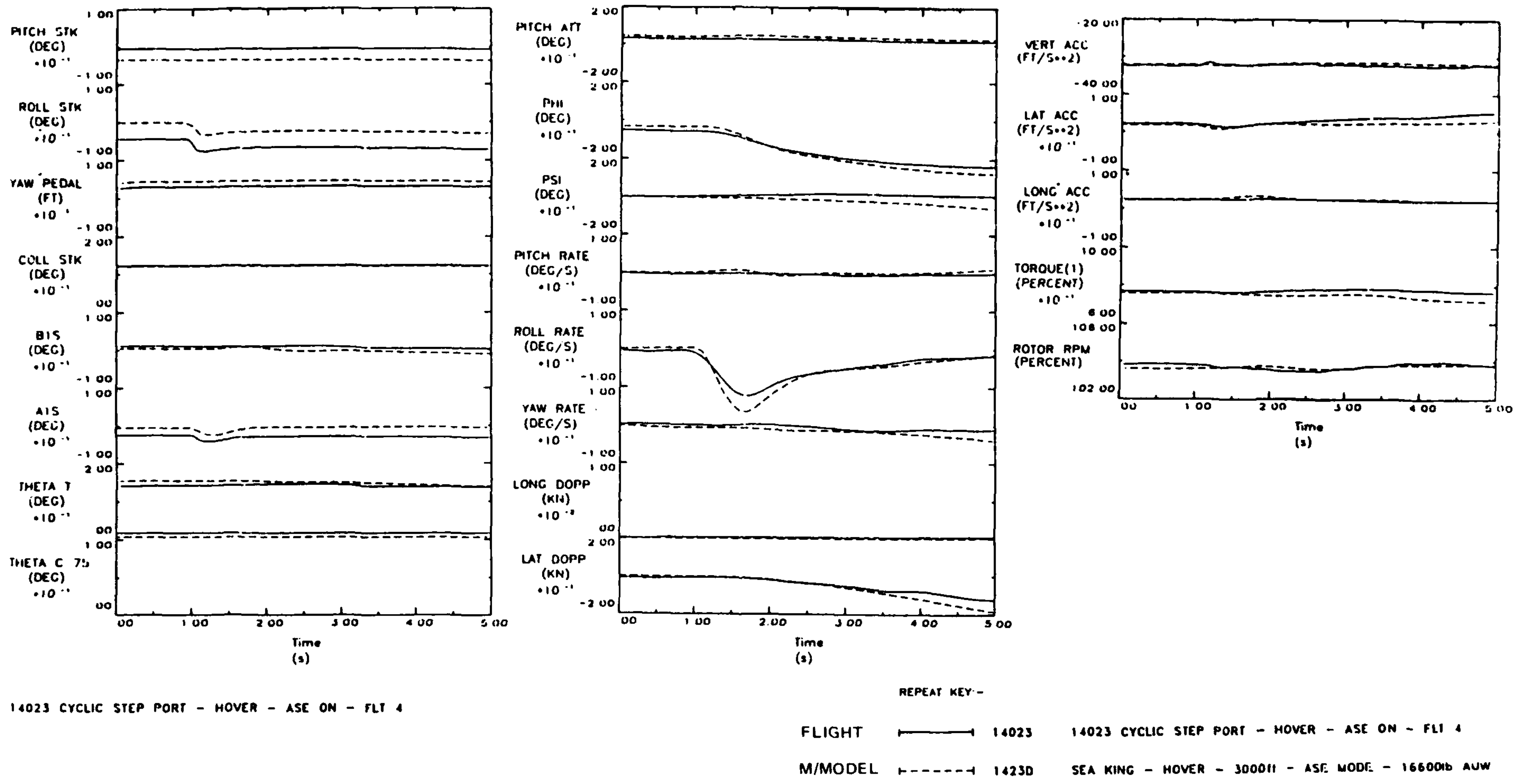


FIG. 6(a) DYNAMIC RESPONSE – LATERAL CYCLIC INPUT

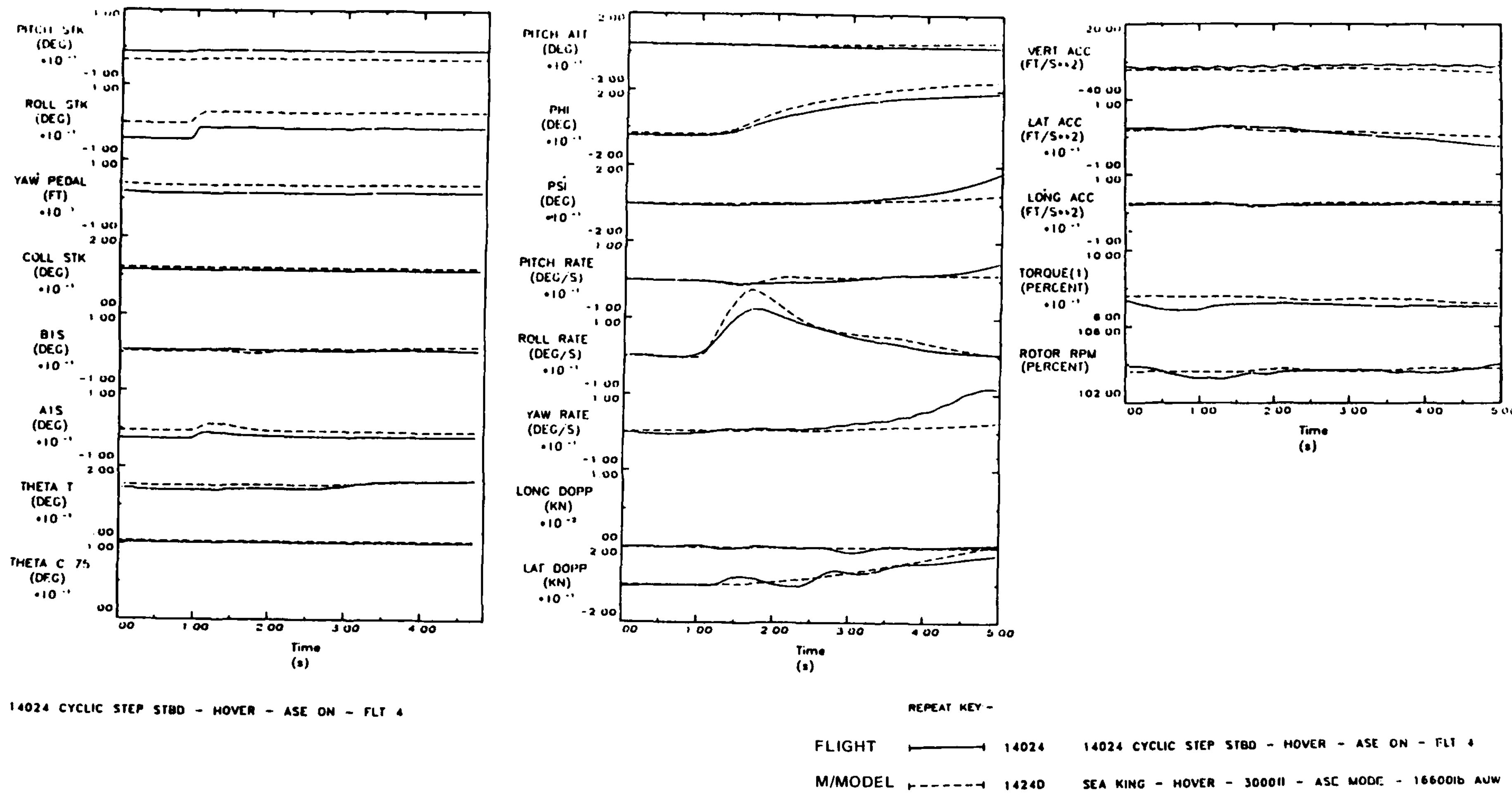


FIG. 6(b) DYNAMIC RESPONSE – LATERAL CYCLIC INPUT

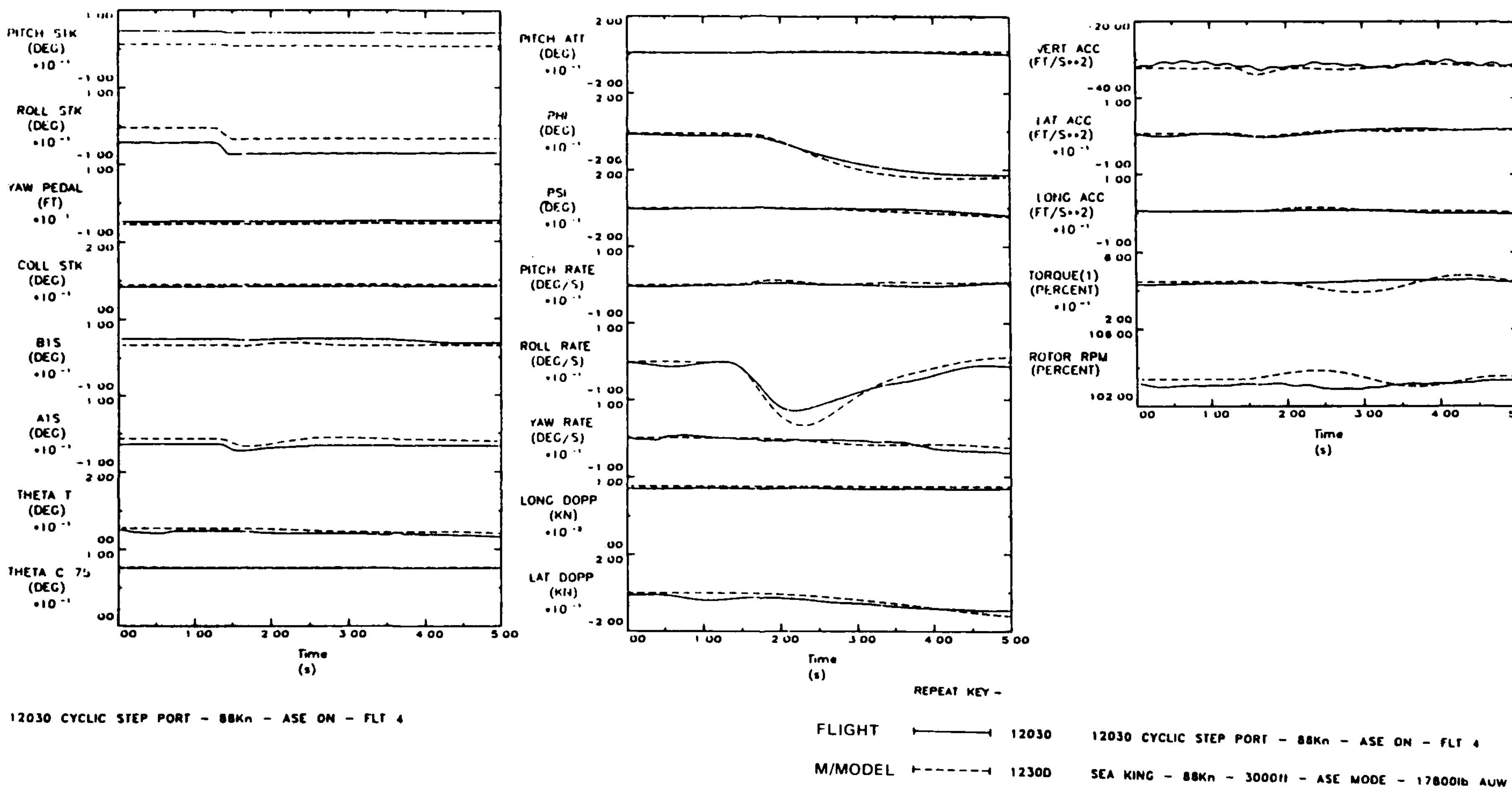


FIG. 7(a) DYNAMIC RESPONSE – LATERAL CYCLIC INPUT

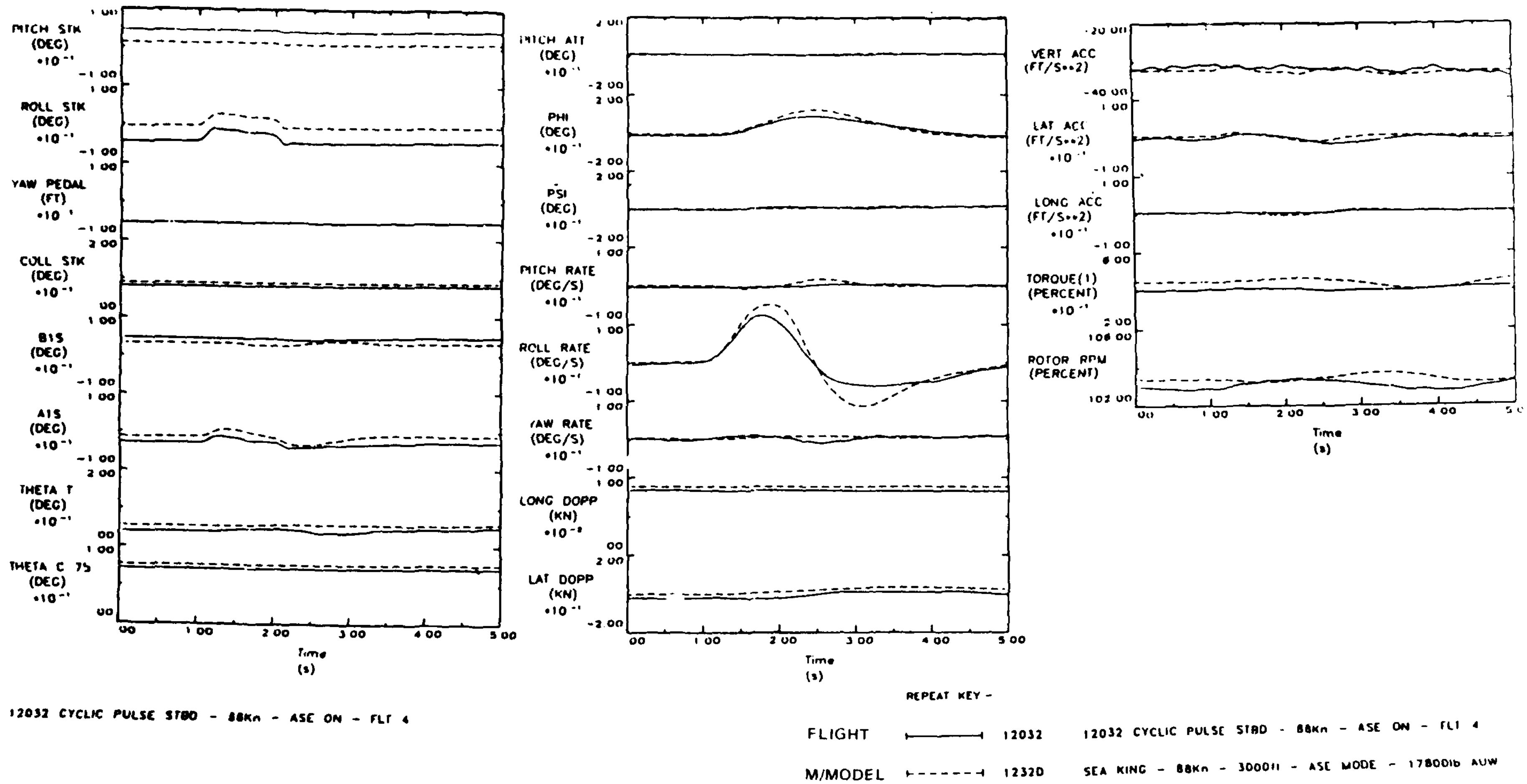


FIG. 7(b) DYNAMIC RESPONSE – LATERAL CYCLIC INPUT

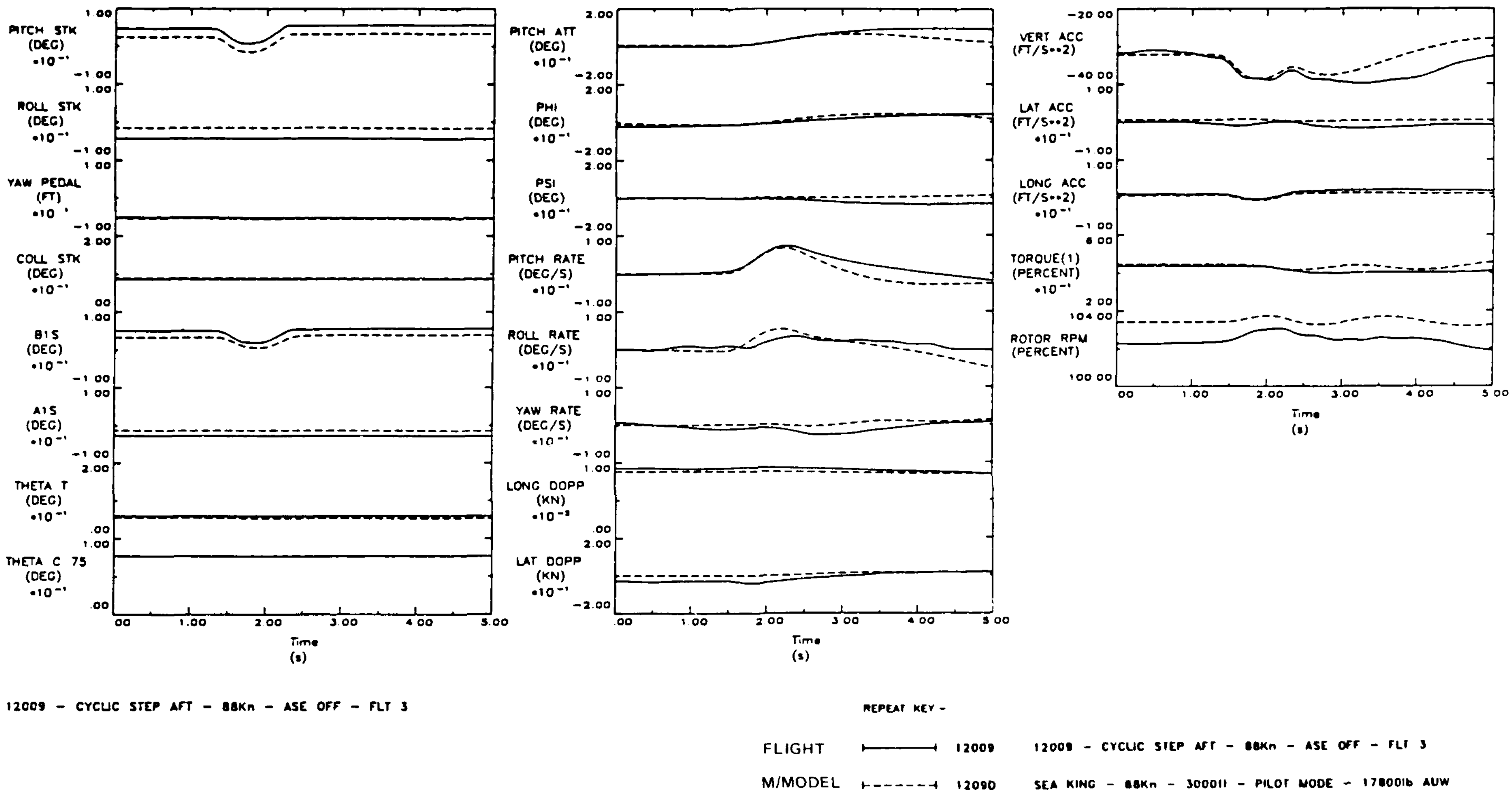


FIG. 8(a) DYNAMIC RESPONSE – LONGITUDINAL CYCLIC INPUT

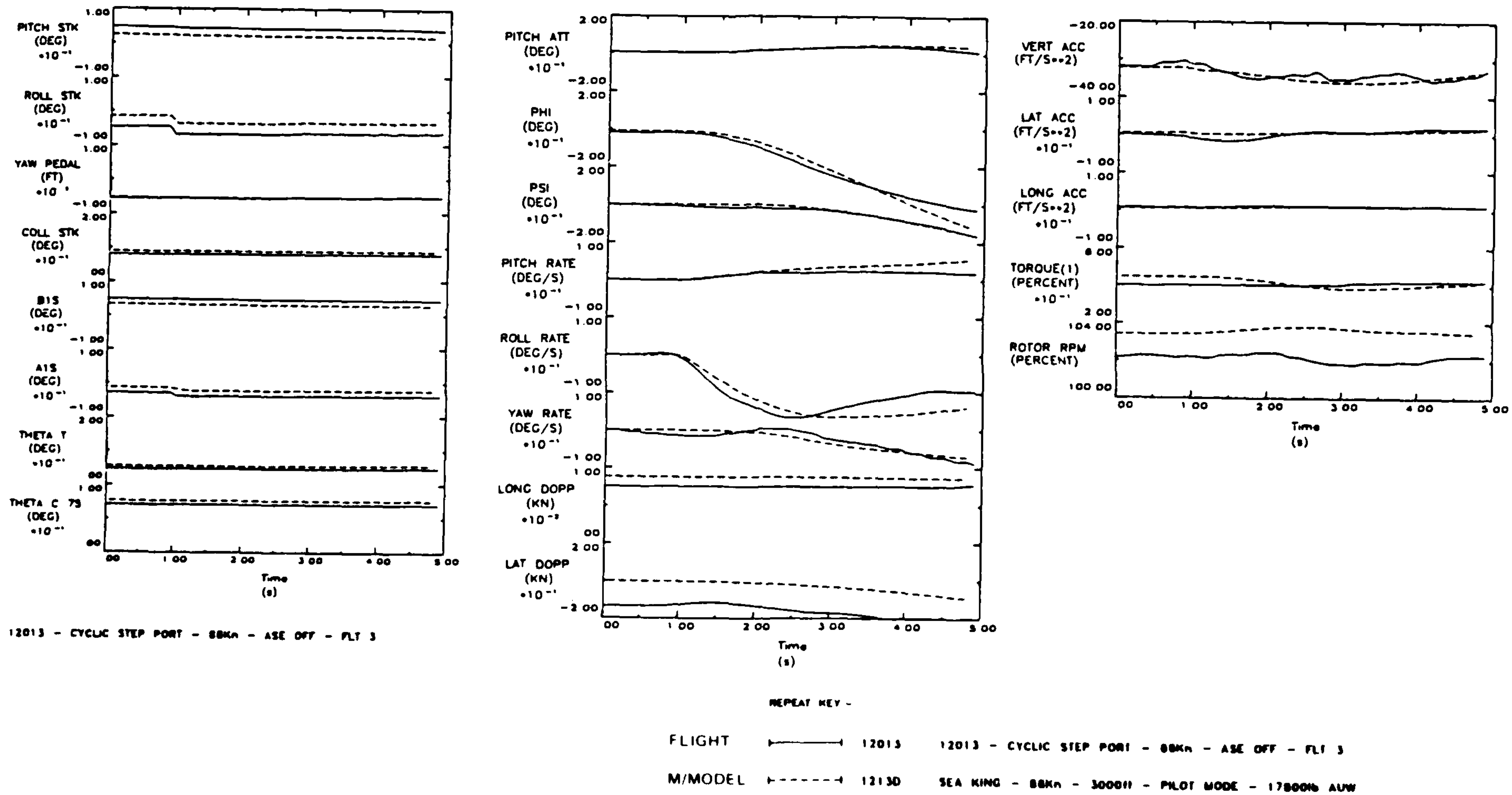


FIG. 8(b) DYNAMIC RESPONSE LATERAL CYCLIC INPUT

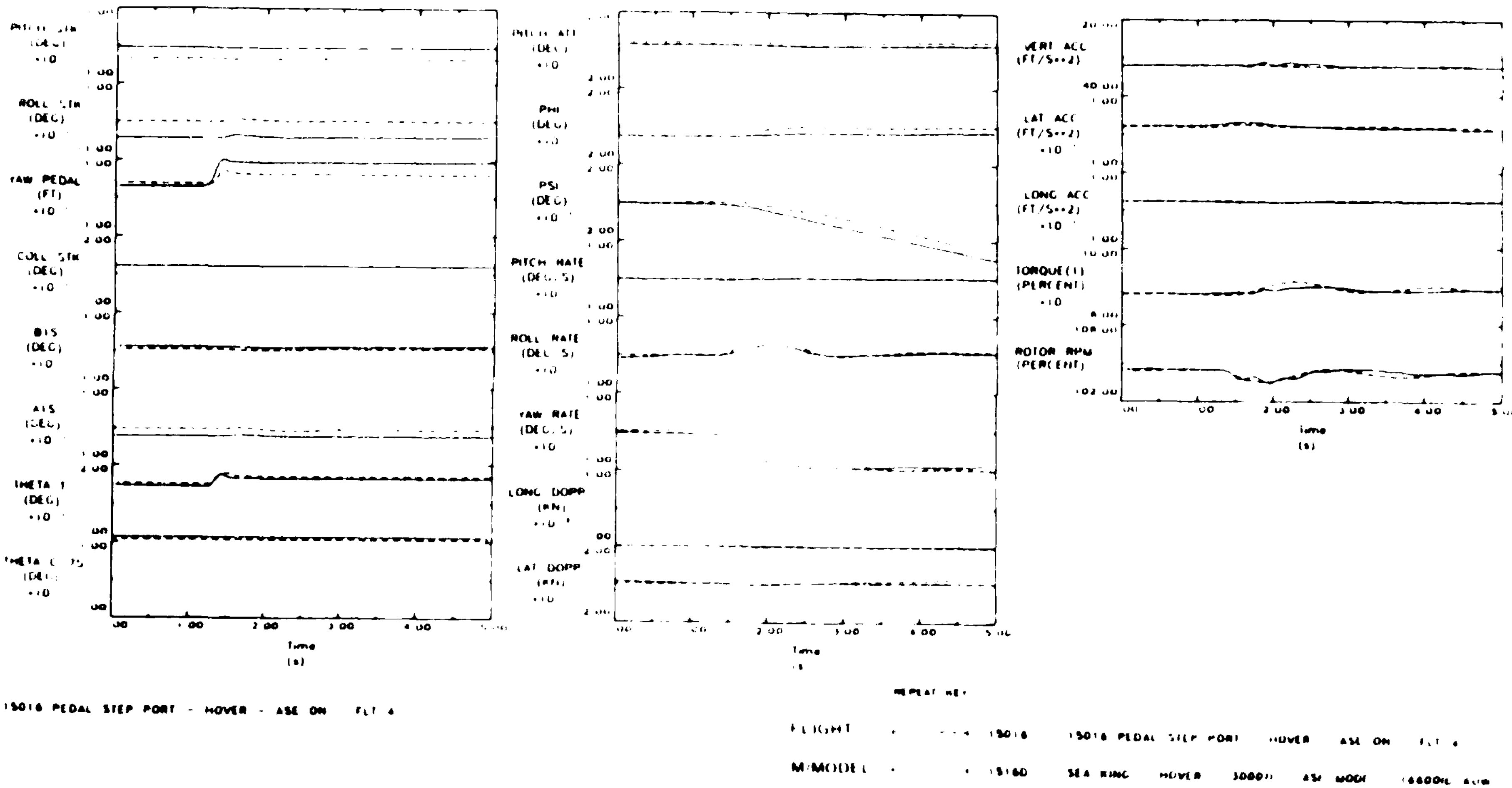


FIG 9(a) DYNAMIC RESPONSE PEDAL INPUT

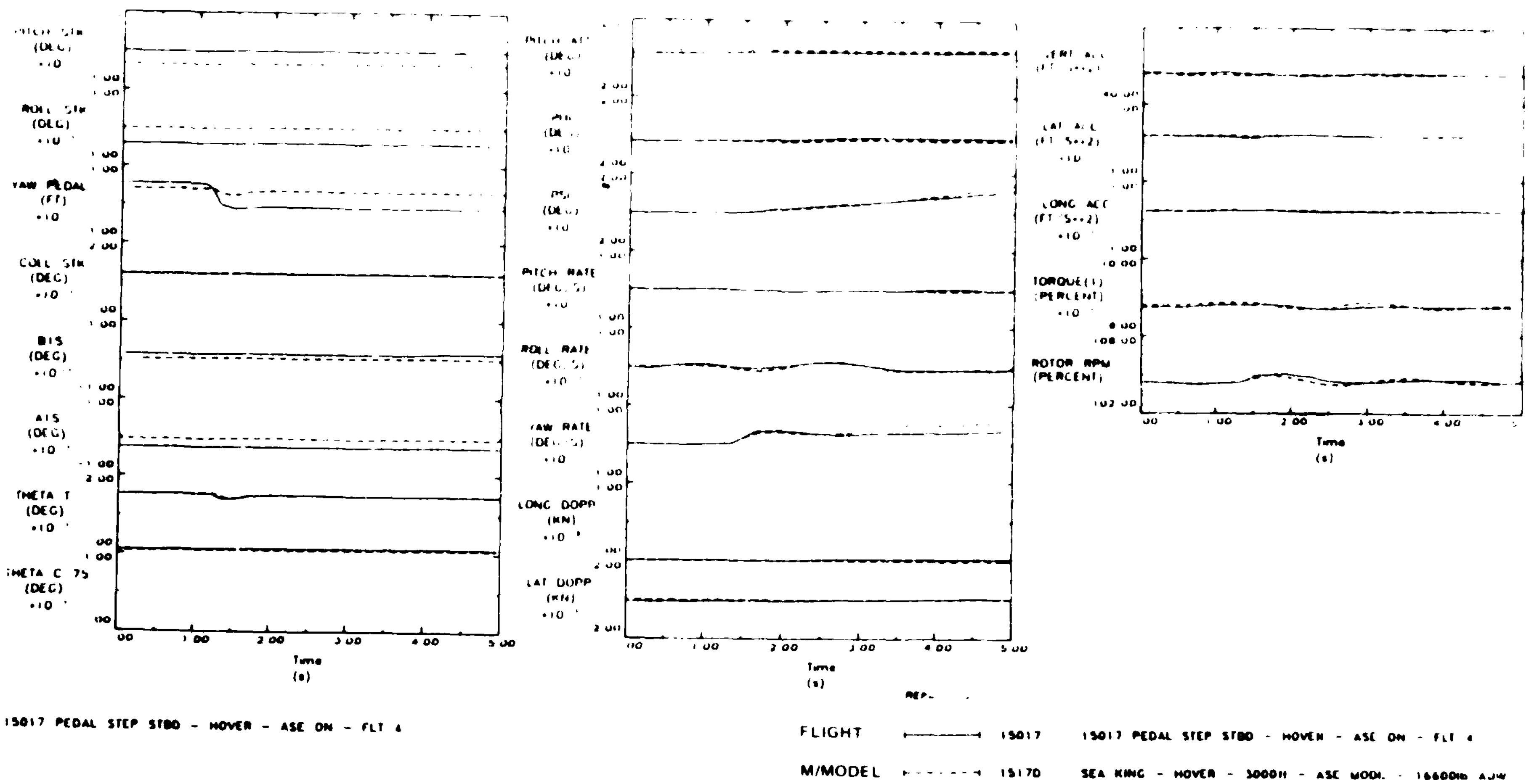


FIG. 9(b) DYNAMIC RESPONSE – PEDAL INPUT

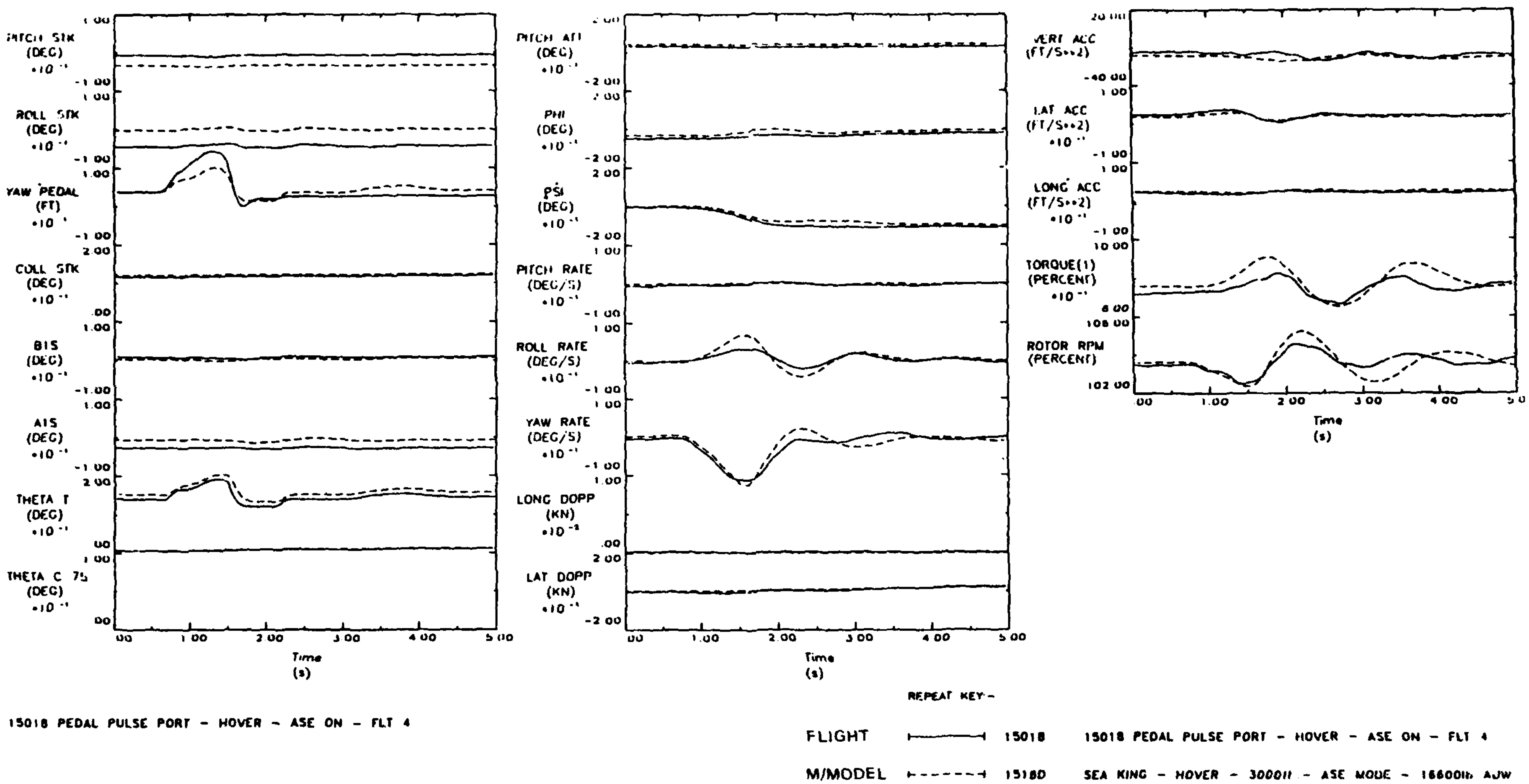


FIG. 9(c) DYNAMIC RESPONSE – PEDAL INPUT

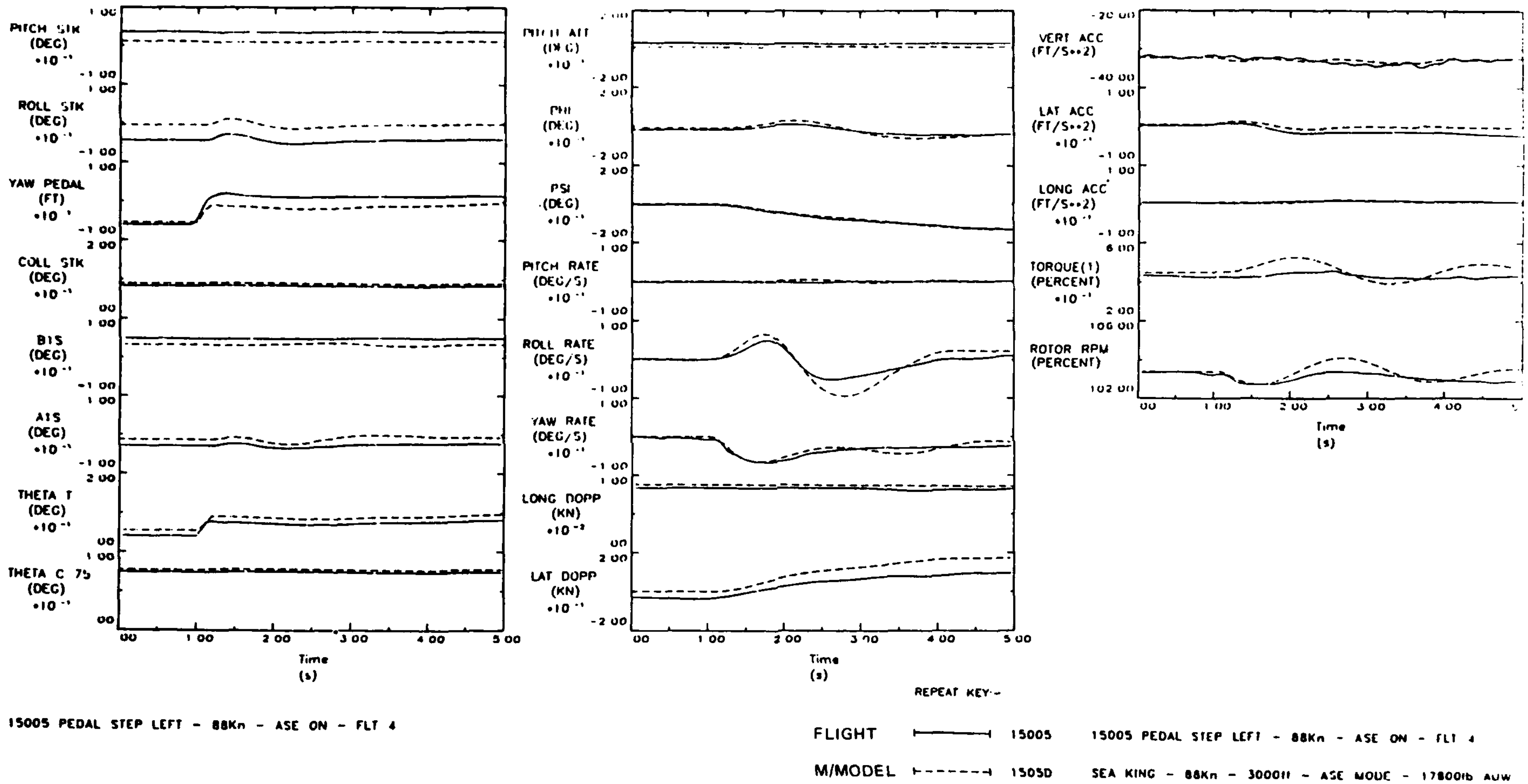


FIG. 10(a) DYNAMIC RESPONSE – PEDAL INPUT

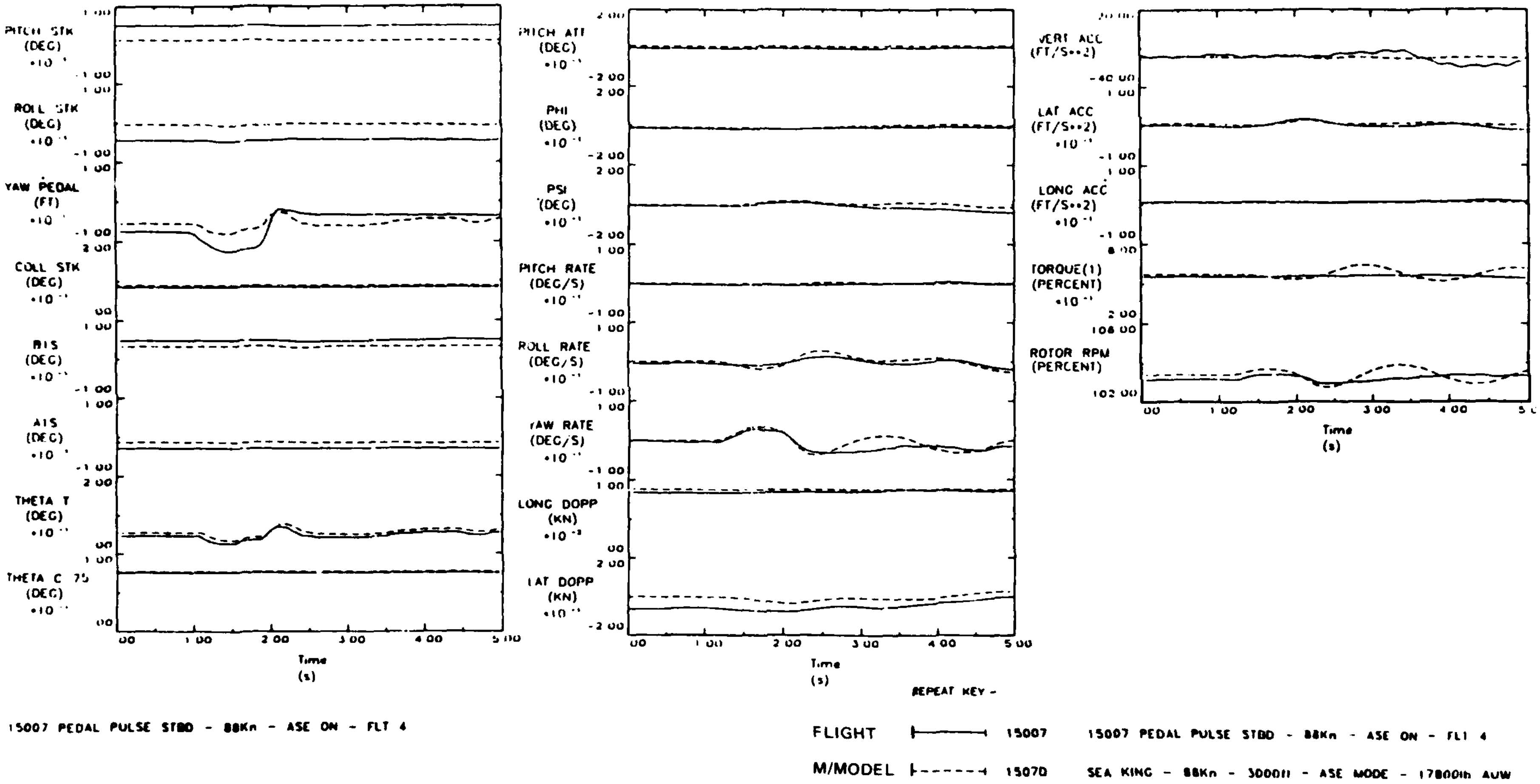
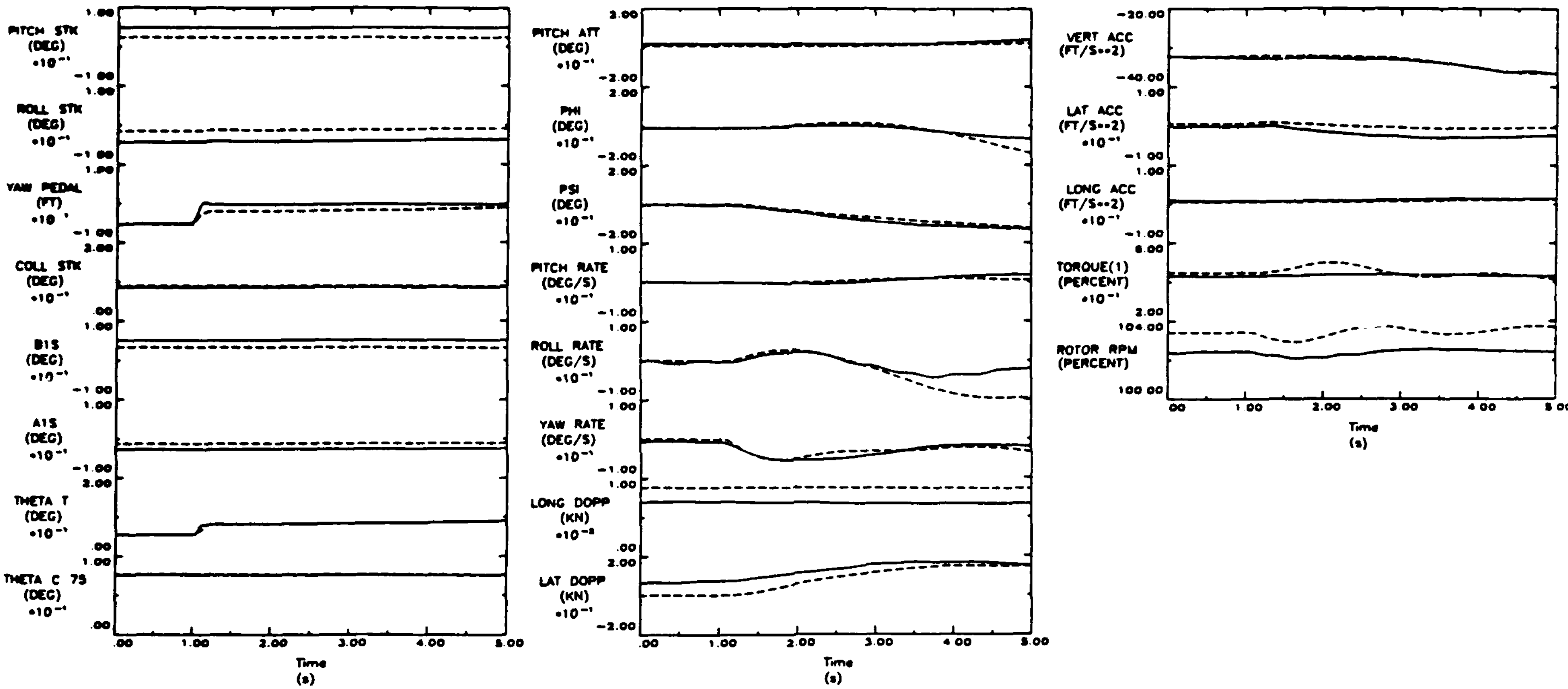


FIG. 10(b) DYNAMIC RESPONSE – PEDAL INPUT



15025 - PEDAL STEP PORT - 88Kn - ASE OFF - FLT 3

REPEAT KEY:-

FLIGHT 15025 15025 - PEDAL STEP PORT - 88Kn - ASE OFF - FLT 3

M/MODEL 15250 SEA KING - 88Kn - 300011 - PILOT MODE - 17800lb AUW

FIG. 10(c) DYNAMIC RESPONSE – PEDAL INPUT

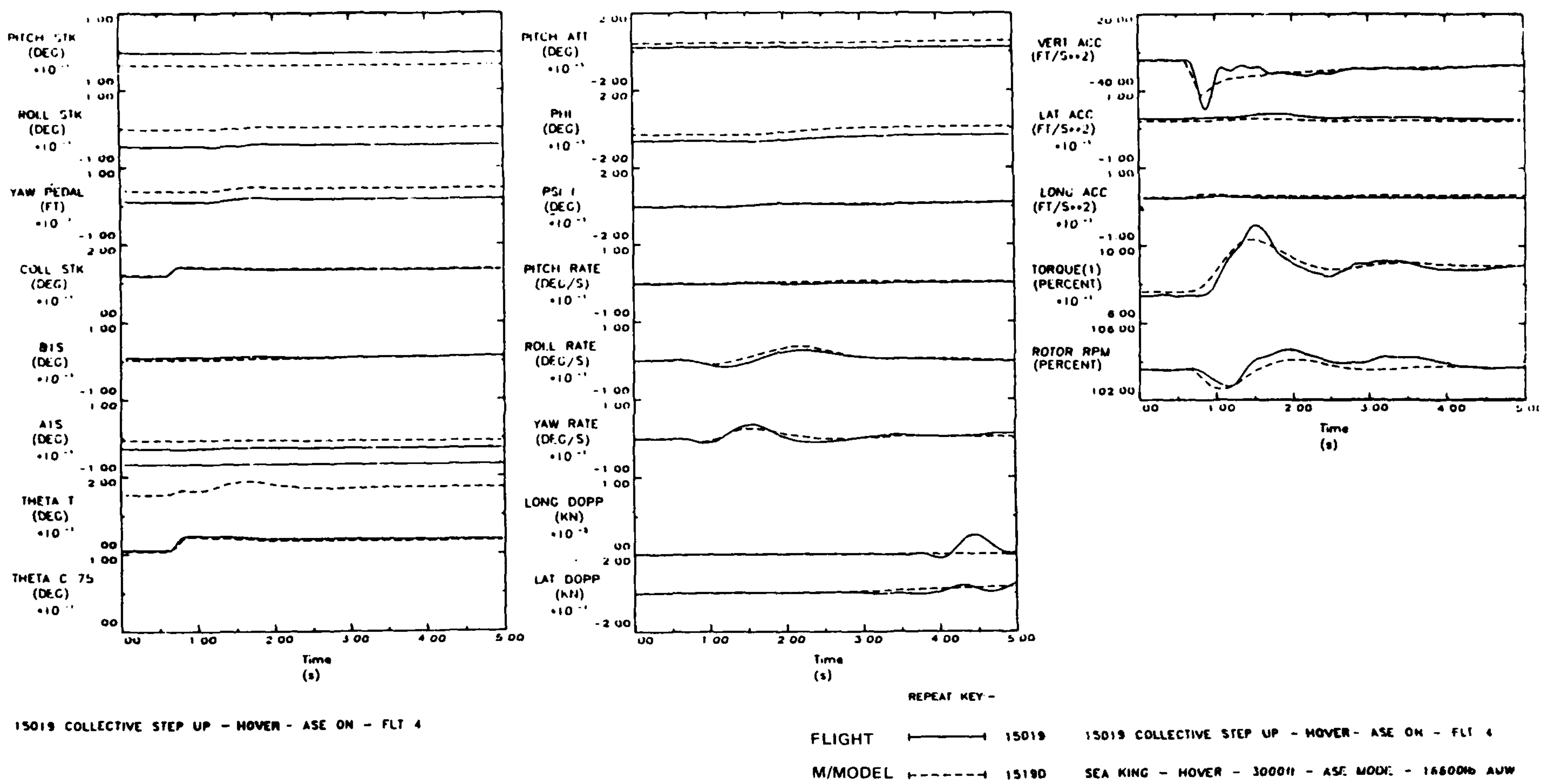


FIG. 11(a) DYNAMIC RESPONSE – COLLECTIVE INPUT

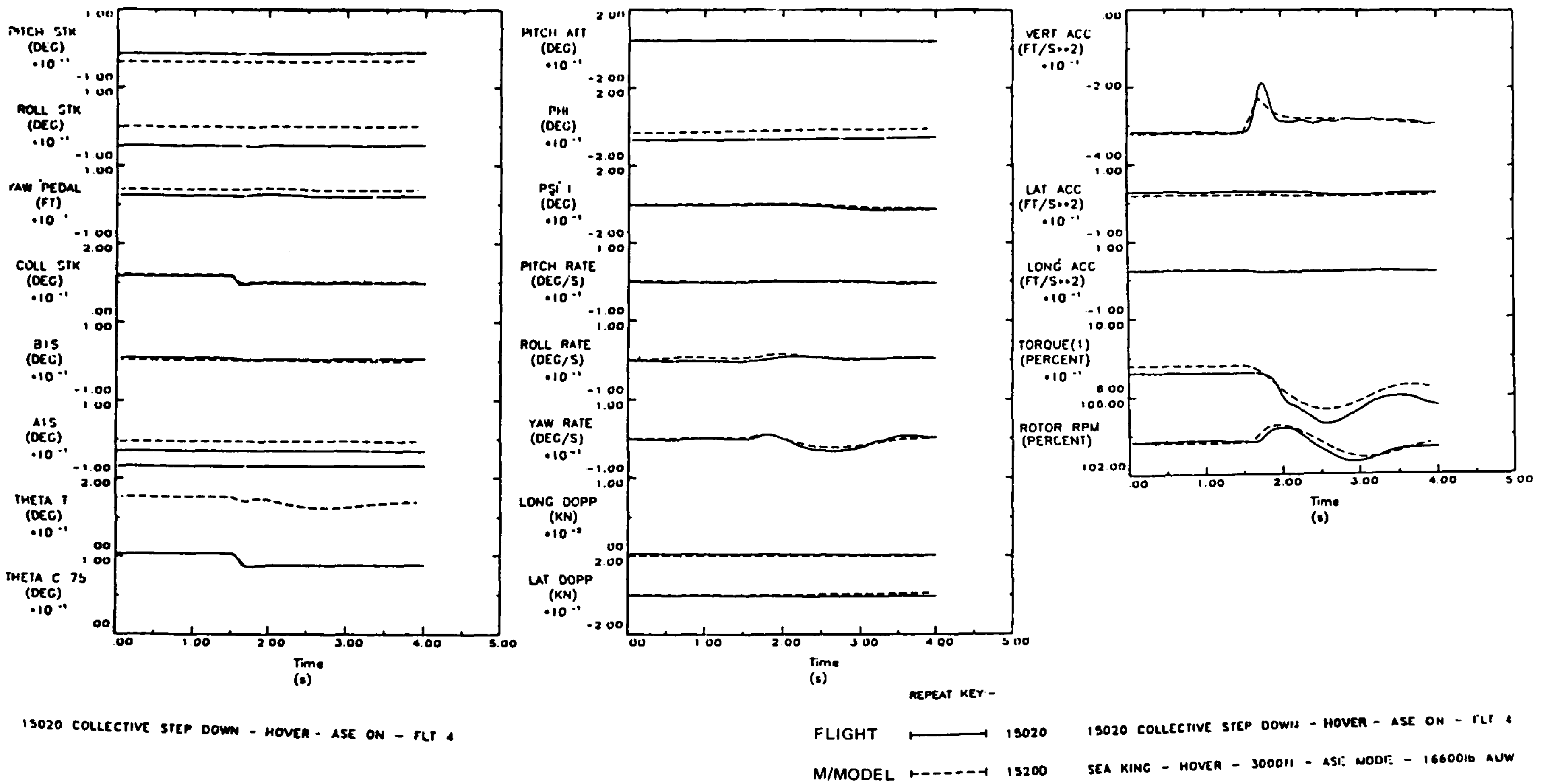


FIG. 11(b) DYNAMIC RESPONSE – COLLECTIVE INPUT

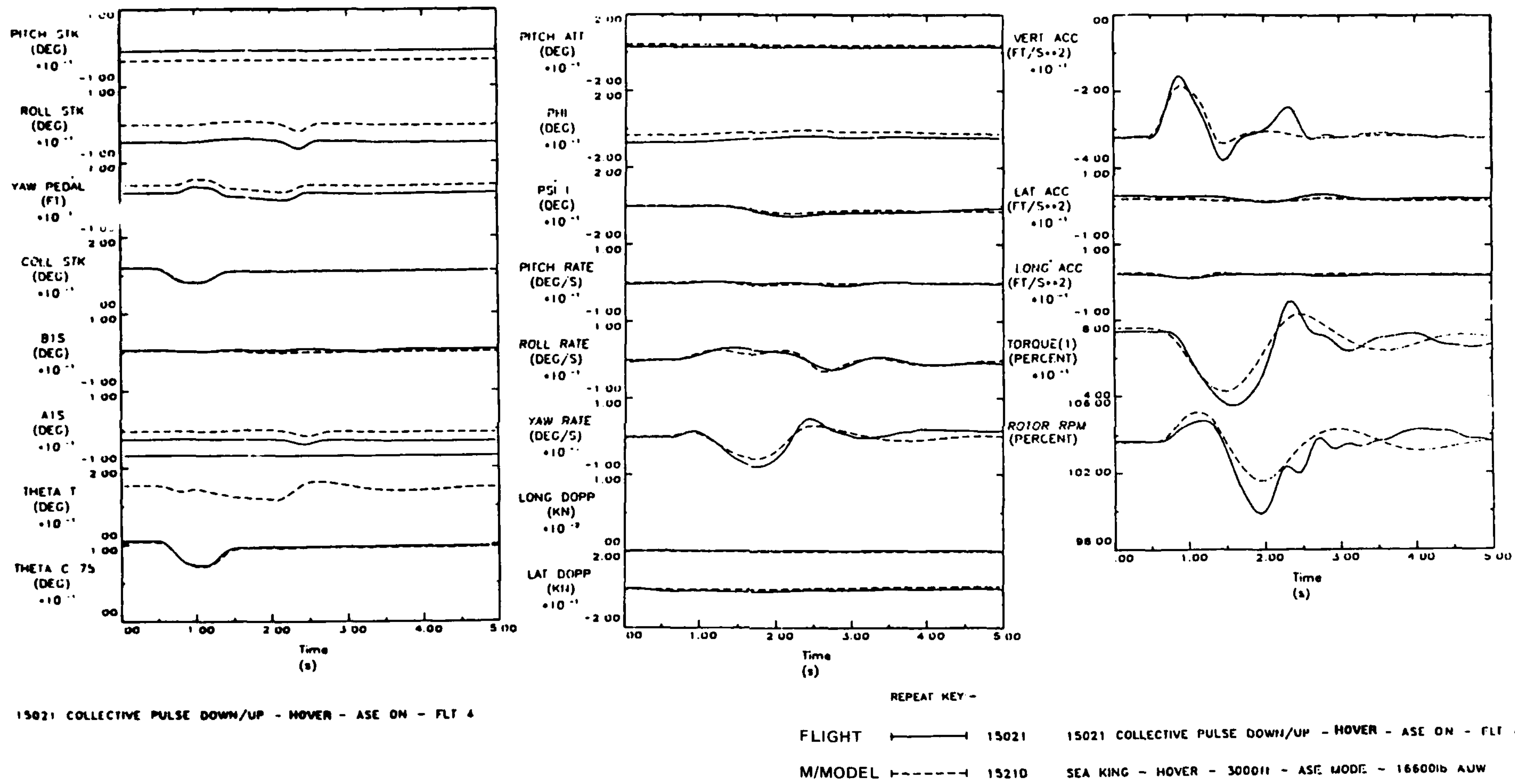


FIG. 11(c) DYNAMIC RESPONSE – COLLECTIVE INPUT

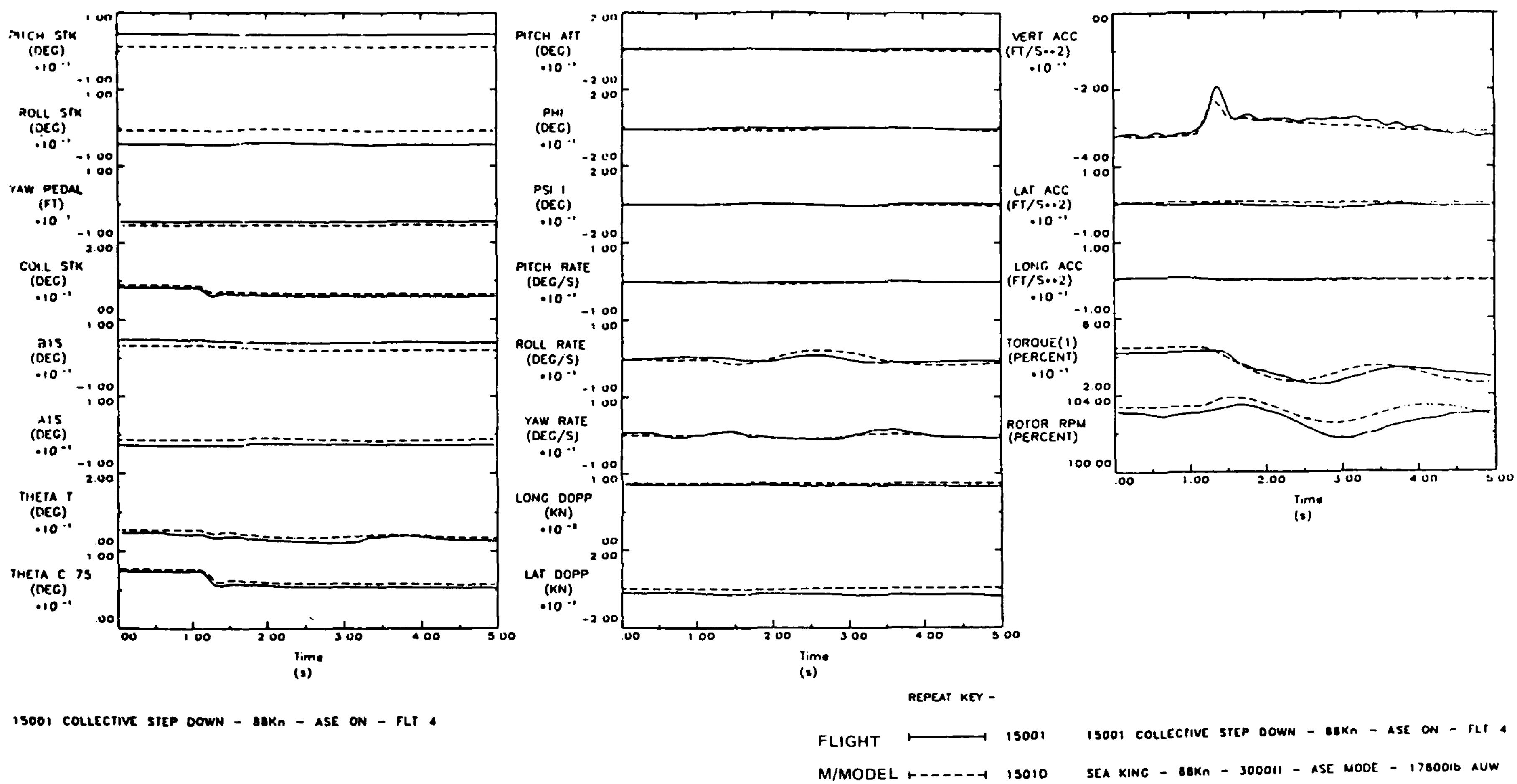
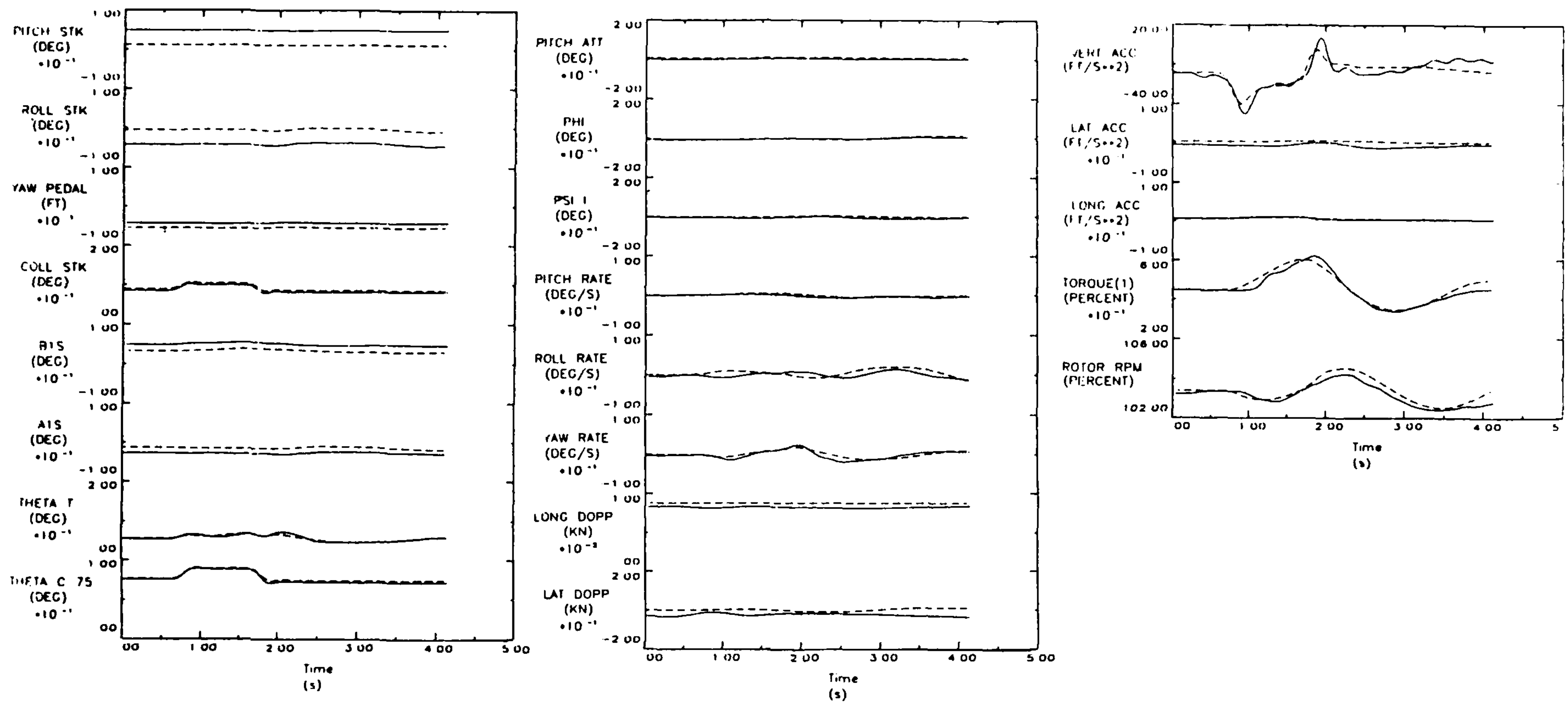


FIG. 12(a) DYNAMIC RESPONSE – COLLECTIVE INPUT



15003 COLLECTIVE PULSE UP 88Kn – ASE ON – FLT 4

REPEAT KEY –

FLIGHT ├────┤ 15003 15003 COLLECTIVE STEP UP – 88Kn – ASE ON – FLT 4

M/MODEL ├------┤ 1503D SEA KING – 88Kn – 3000ft – ASE MODE – 17800lb AUW

FIG. 12(b) DYNAMIC RESPONSE – COLLECTIVE INPUT

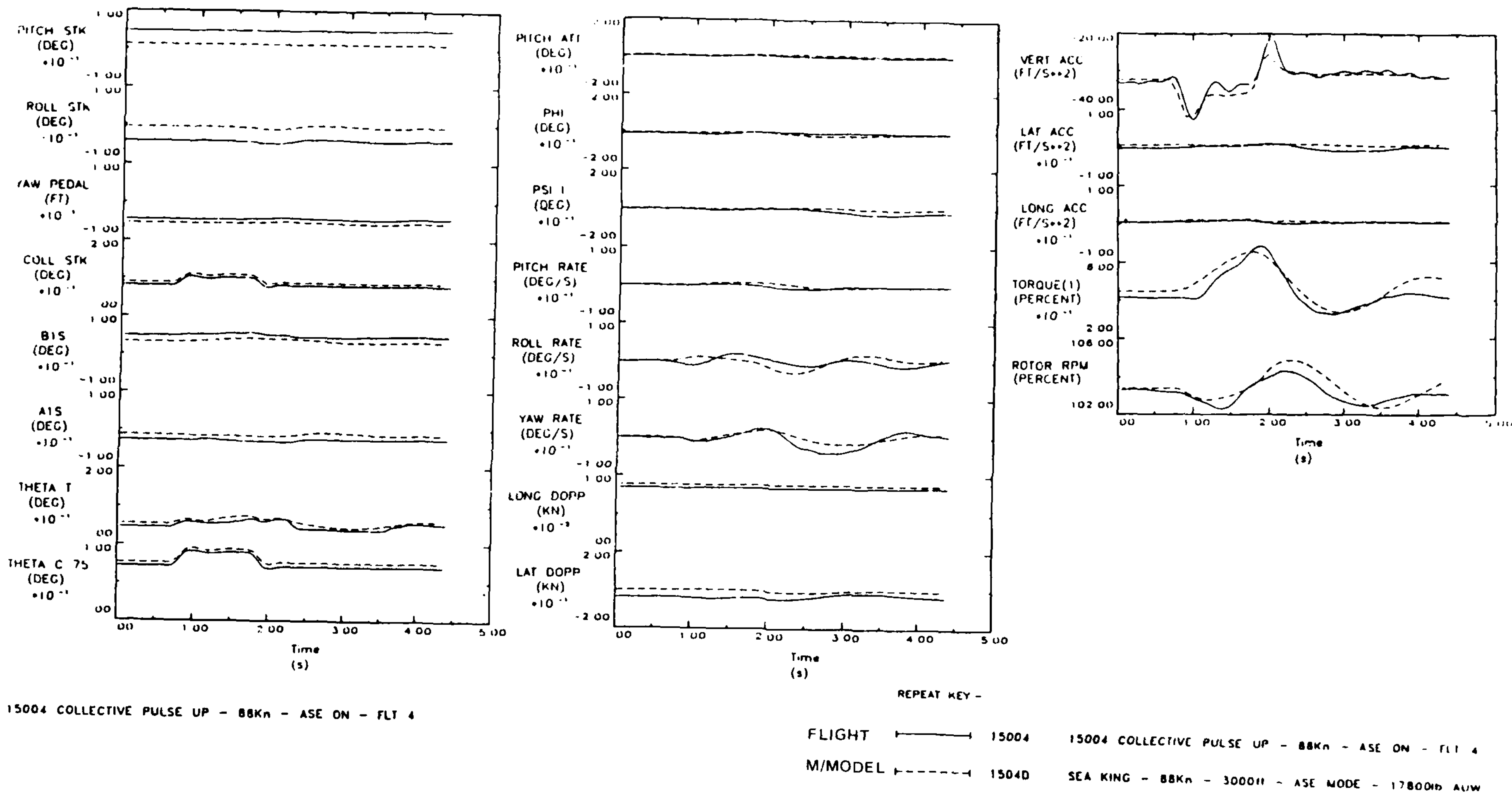


FIG. 12(c) DYNAMIC RESPONSE – COLLECTIVE INPUT

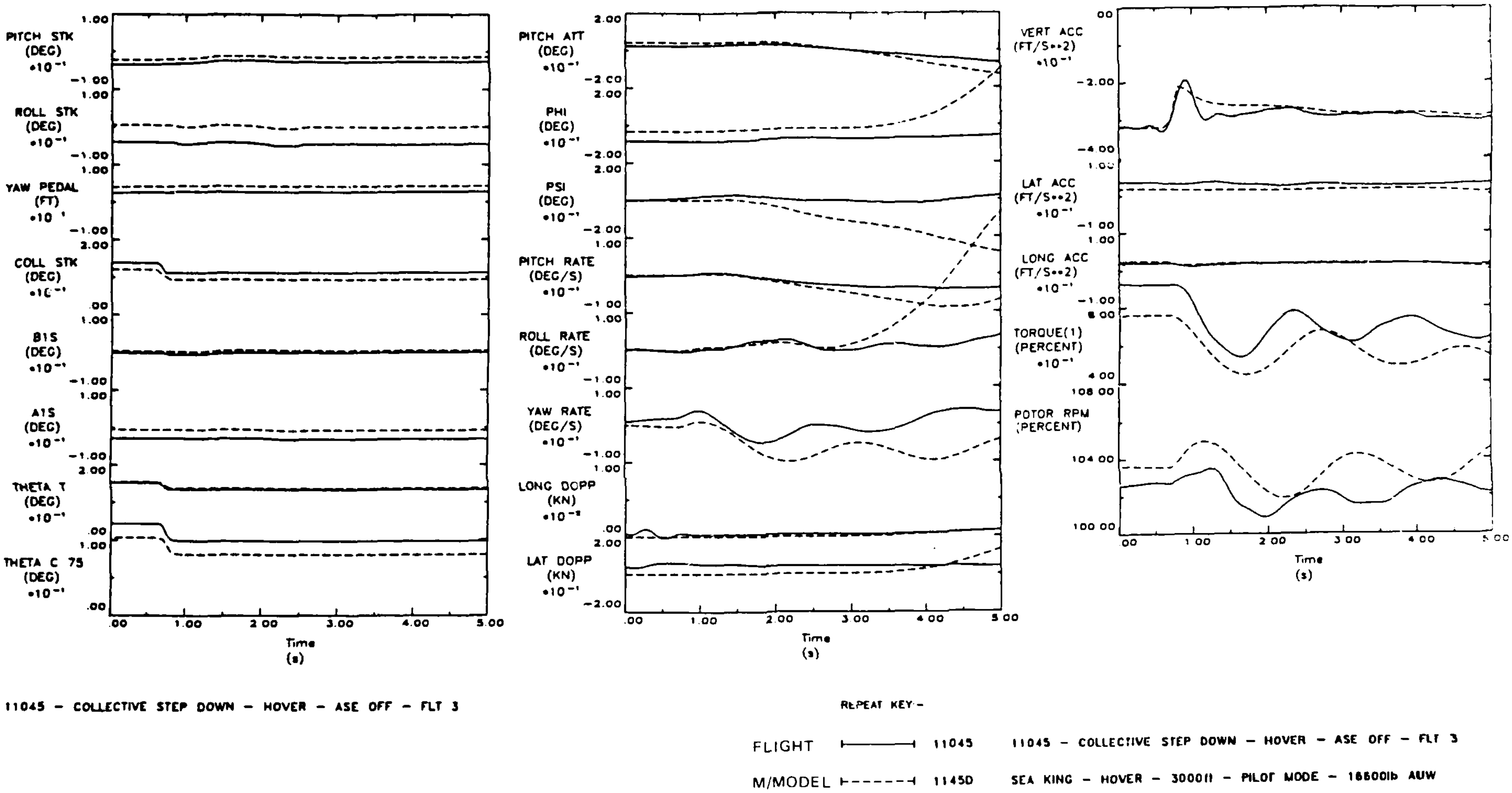


FIG. 13 DYNAMIC RESPONSE – COLLECTIVE INPUT

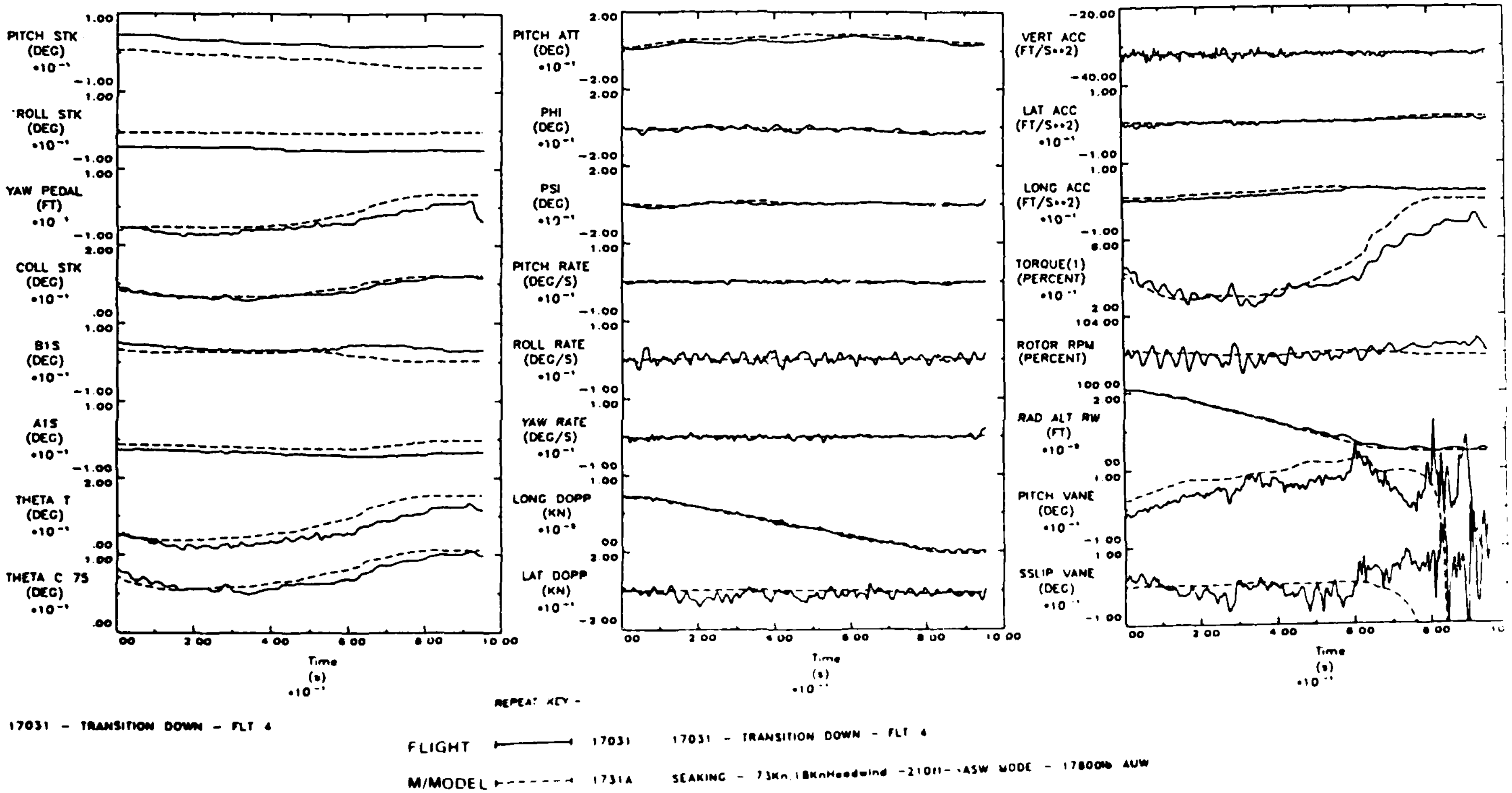


FIG. 14(a) TRANSITION DOWN

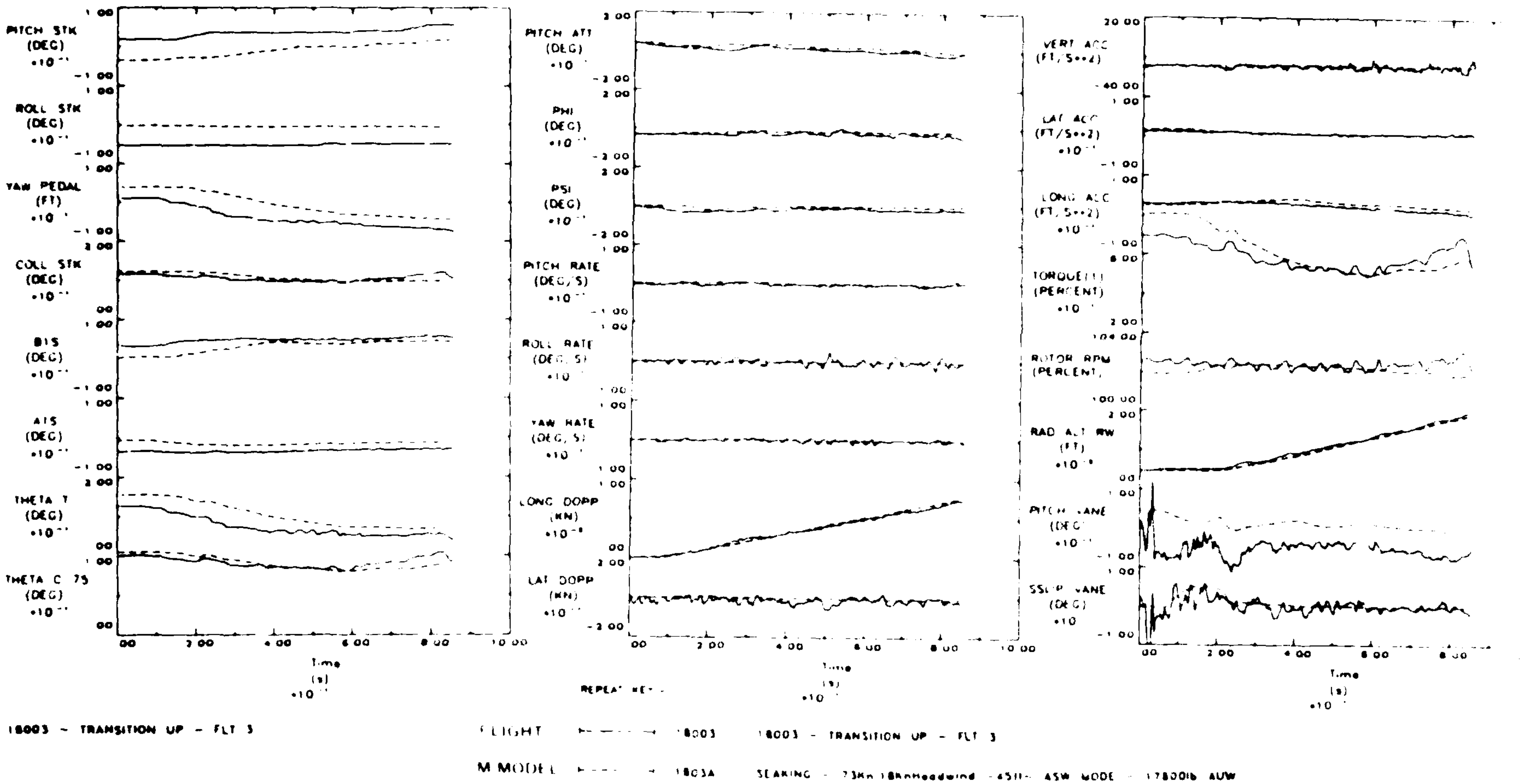
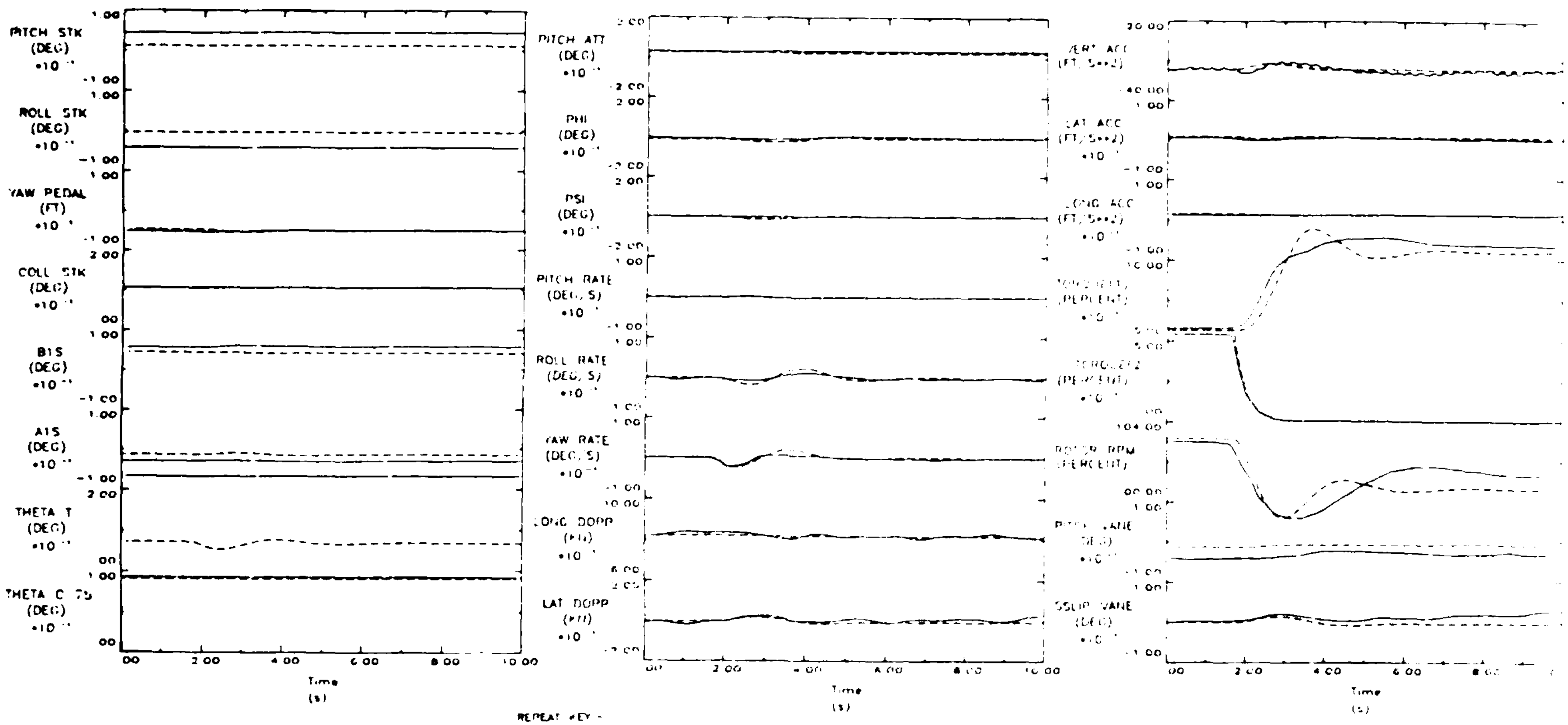


FIG. 14(b) TRANSITION UP



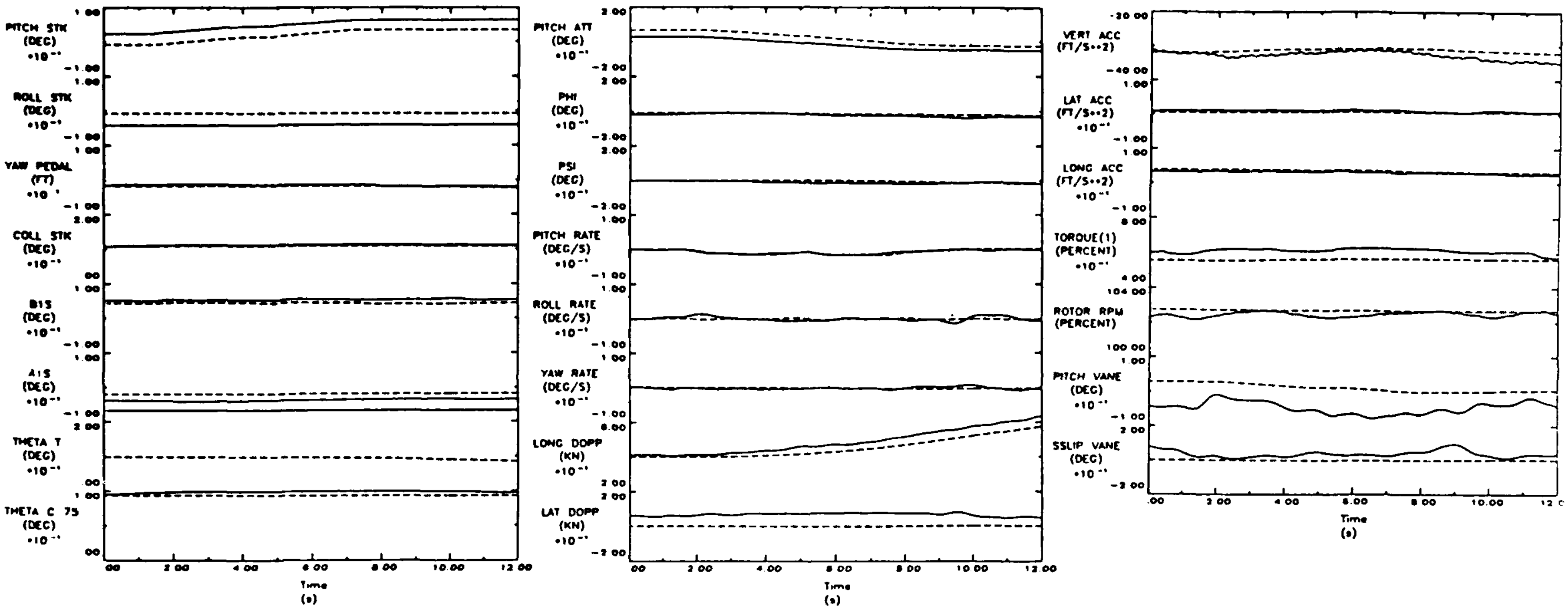
REPEAT KEY -

19092 - ENGINE 2 CUT - FLT 4

FLIGHT ———— 19092 19092 - ENGINE 2 CUT - FLT 4

M/MODEL - - - - - - 19920 SEA KING - 82kn 4deg climb - Eng 2 cut - ASE MODE - 17800lb

FIG.15 ENGINE CUT – SIMULATED FAILURE OF ENGINE



18014 - FWD BEEP - 40Kn - FLT 4

REPEAT KEY -

FLIGHT ├──────┤ 18014   18014 - FWD BEEP - 40Kn - FLT 4

M/MODEL ├- - - - - -┤ 18148   SEAKING-40Kn,4deg climb,beep fwd-3000ft-ASE MODE-19200lb

FIG. 16(a) BEEPING TRIM INPUT

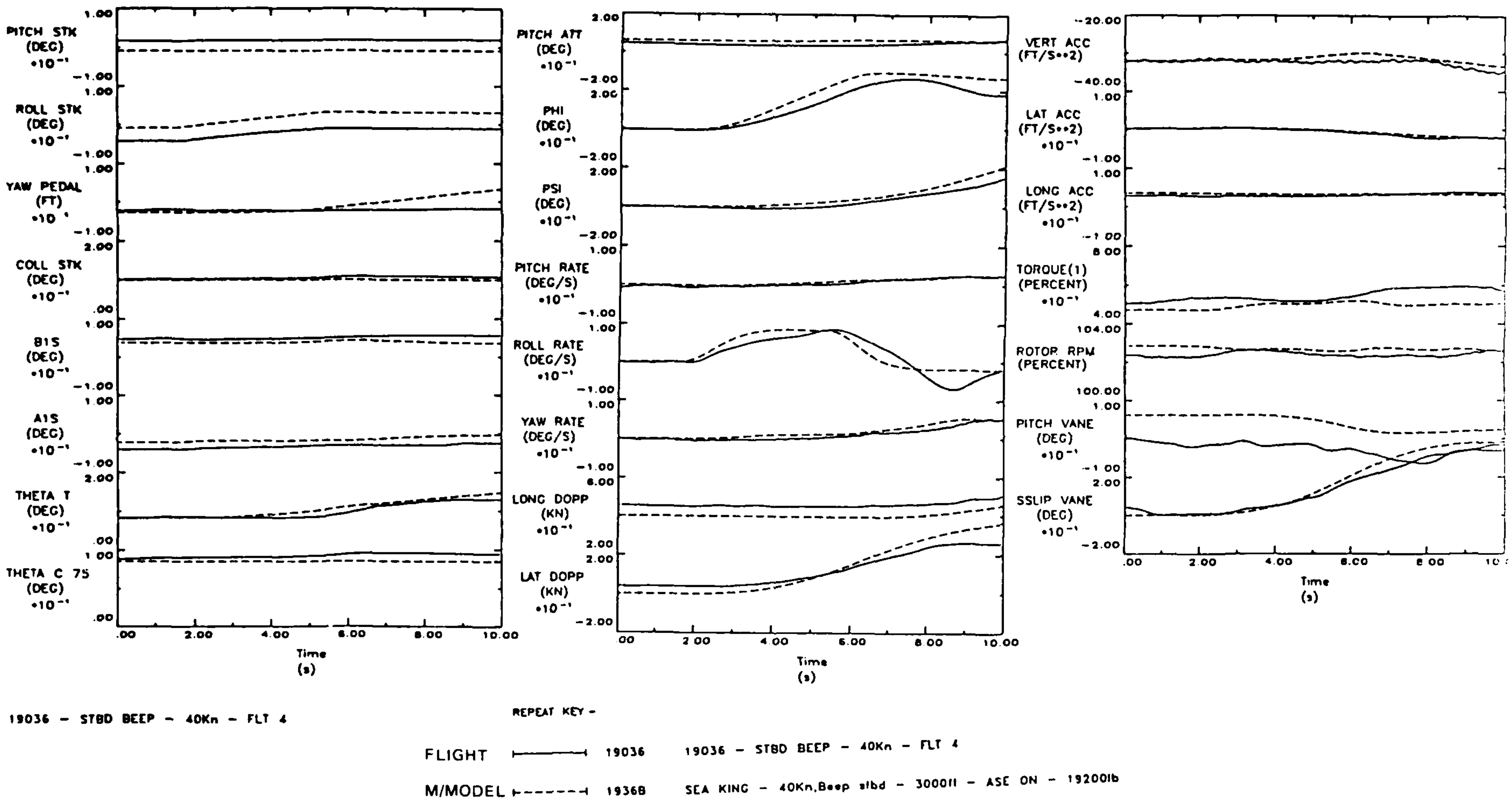


FIG. 16(b) BEEPING TRIM INPUT

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16. Abstract

A mathematical model of the Sea King Mk 50 helicopter has been developed at ARL to allow prediction of the aircraft flight behaviour for a wide range of specified conditions. Validation of the model has been performed by successive comparisons with flight data and model adjustment to achieve acceptable overall agreement. Such comparisons have been made for trimmed flight, dynamic responses to control inputs and automatic transitions associated with the ASW role. Some remaining deficiencies in the model could be addressed by modifications tailored to a specific application.

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